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Ministry of Energy, Mines and
Petroleum Resources
Hon. Jack Davis, Minister

MINERAL RESOURCES DIVISION
Geological Survey Branch

A MINERAL RESOURCE ASSESSMENT OF THE CHILKO LAKE PLANNING AREA

By Graeme P. McLaren

Province of British Columbia BC
Ministry of Energy, Mines and Petroleum Resources
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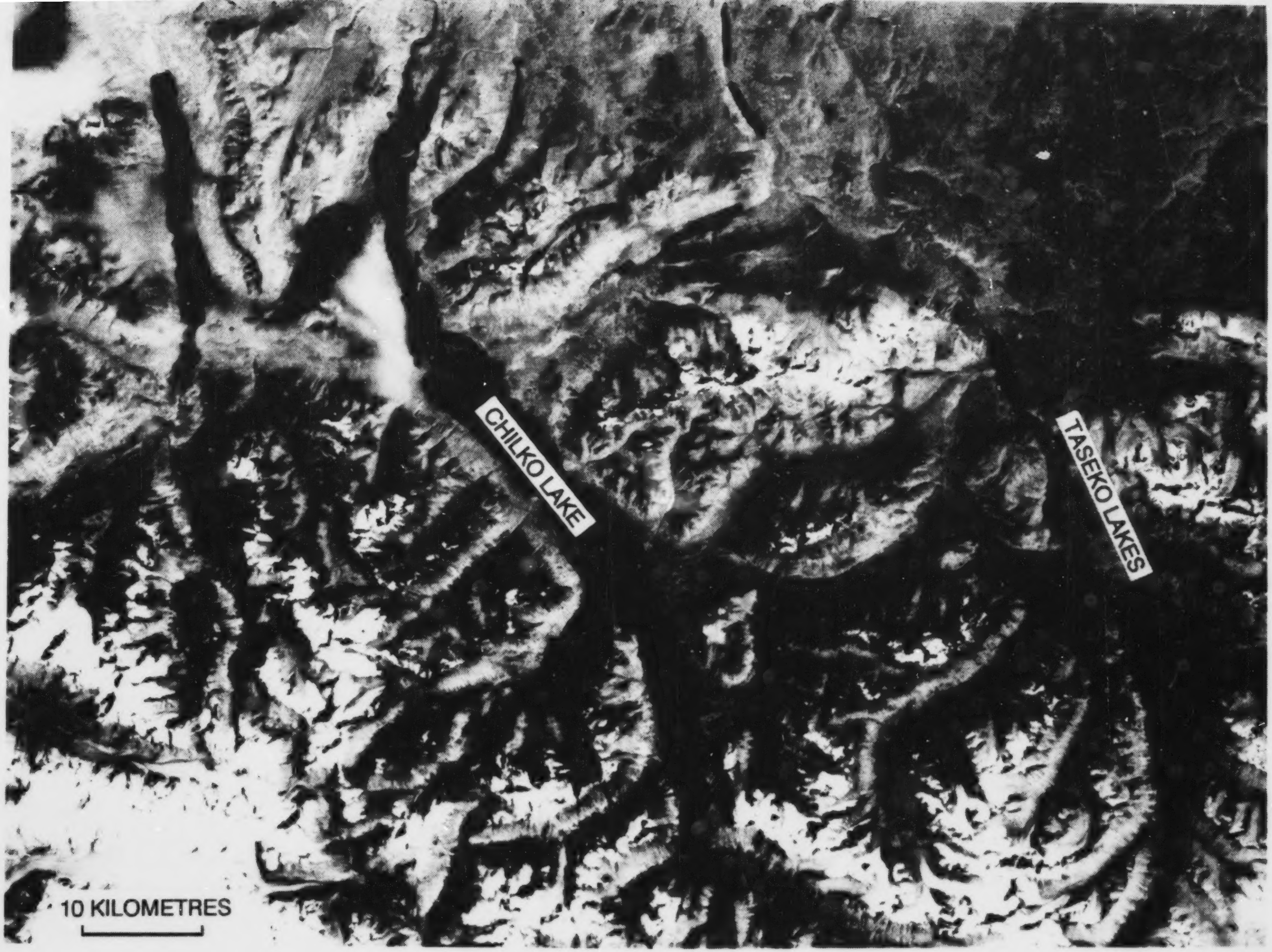
CHILKO LAKE
TASEKO LAKES
10 KILOMETRES

Landsat V Image of the Chilko-Taseko Lakes Area

PREFACE: A GUIDE TO THIS BULLETIN

This report is intended to reach two primary audiences and has a dual purpose: 1) to provide geoscientific data to earth science professionals in industry, government and the academic community, and 2) to discuss and illustrate mineral potential to others such as land-use planners and the interested public. For those with limited interest in detailed geoscientific data, the initial 'Introduction' and final 'Mineral Potential' chapters, together with the introductory statements in the chapters covering 'Geology', 'Geochemistry' and 'Mineralization' should convey all the concepts necessary to appreciate the mineral potential designations assigned in this study.

SUMMARY

The Chilko Lake Planning Area encompasses a portion of the transition zone between the rugged mountains of the Coast Ranges and the rolling terrain of the Interior Plateau in south-central British Columbia. It comprises an area of scenic beauty with high wildlife and recreational resource values that has long been studied as a candidate for a provincial park. However, it also covers a region of high mineral potential. This mineral resource assessment was undertaken to determine the mineral potential of the planning area in detail, in order that informed decisions can be made regarding the boundaries of any future provincial park proposal. A program of 1:50 000-scale geological mapping, detailed stream-sediment sampling, and prospecting with extensive rock chip sampling was conducted to identify the mineral potential.

Two broad geologic assemblages are present in the Chilko Lake Planning Area; an intrusive assemblage related to the Coast Mountains extends across the south and southwestern border of the area while a volcanic-sedimentary assemblage underlies the remainder (Figure i). Diverse geological environments, typical of the convergent plate margin setting of western North America, are present in the two broad assemblages. These environments developed in response to terrane collisions and subsequent uplift of the Coast plutonic complex. The stratigraphy of the area records a predominantly Early Cretaceous volcanic island arc environment that interfingers with the clastic sedimentary environment of the Tyaughton trough. The products of widespread Late Cretaceous volcanism overly the older rocks. This succession has been truncated by the Coast Mountain intrusions on the southwest as well as by numerous smaller intrusive stocks and dikes. Extensive northwest-trending transcurrent fault zones, some with displacements measuring tens of kilometres, transect the map area. Northeast-trending faults are younger and have limited displacements. Northeasterly directed thrust faults and high-angle reverse faults may be related to uplift of the Coast Mountains.

Stream-sediment geochemical data for the area are characterized by distinct populations from the volcanic/sedimentary succession and the Coast plutonic complex. Anomalous metal concentrations, determined by probability plot analysis, successfully identified known mineralization as well as other zones worthy of follow-up exploration. These anomalous zones generally follow structural or intrusive trends, that is, those zones most favourable for metallogenic processes. Lithogeochemical data acquired from mineralization or associated alteration assemblages were classified by mode of occurrence of the material sampled and further characterized metallogenic models applicable to the area. The geochemical data, in conjunction with the geological mapping, give strong indications that structurally controlled precious metal vein deposits, intrusion-related porphyry copper or molybdenum deposits, and volcanogenic massive sulphide deposits may be present in the area. Limited data also suggest the potential for copper-tungsten skarn deposits.

Metallogenic environments typical of a convergent plate margin setting are found throughout the Chilko Lake Planning Area. Mesothermal and epithermal precious metal vein mineralization related to the Coast Range intrusives is well documented, as at the Pellaire occurrence, and in the major structural zones, as at the Vick and Charlie gold occurrences, the Alexis mercury-copper occurrences and the Twin Creek arsenic and copper-gold occurrences discovered during the course of this project. The exploration for similar vein deposits currently being conducted in the adjacent Taseko River to Gold Bridge area provides an incentive for locating new precious metal vein deposits in the correlative but less explored rocks of the Chilko Lake study area. Porphyry copper-molybdenum (± gold) mineralization, similar to the Fish Lake deposit immediately adjacent to the study area, is known at the Charlie occurrence and at the newly discovered Tarn Creek occurrence. Similar minor mineral showings suggest a wider potential for this type of deposit. Copper-tungsten skarn mineralization is known at the Daisie occurrence. Gossanous zones with minor copper mineralization in rhyolitic volcanic horizons indicate the potential for volcanogenic massive sulphide mineralization in rocks thought to be correlative with those hosting the Britannia mine orebodies near Squamish.

The mineral potential of the planning area is believed to be relatively high. The area lies along the trend of numerous mineral occurrences that follows the border of the Coast plutonic complex through British Columbia. Surveys conducted in this project have confirmed this high potential; four significant new mineral showings and a number of new minor occurrences have been discovered. A mineral potential classification utilizing the three types of data determined in this project (geological, geochemical and mineral occurrence) has been developed and provides a semiquantitative measure of the relative mineral potential within the map area. Qualitative descriptions of the mineral potential levels identify the degree of confidence underlying the mineral potential classes and provide an indication of expected future exploration in an area. Zones of high potential are confidently defined in the vicinity of known mineral occurrences. Surrounding these, zones of moderate potential are outlined by the

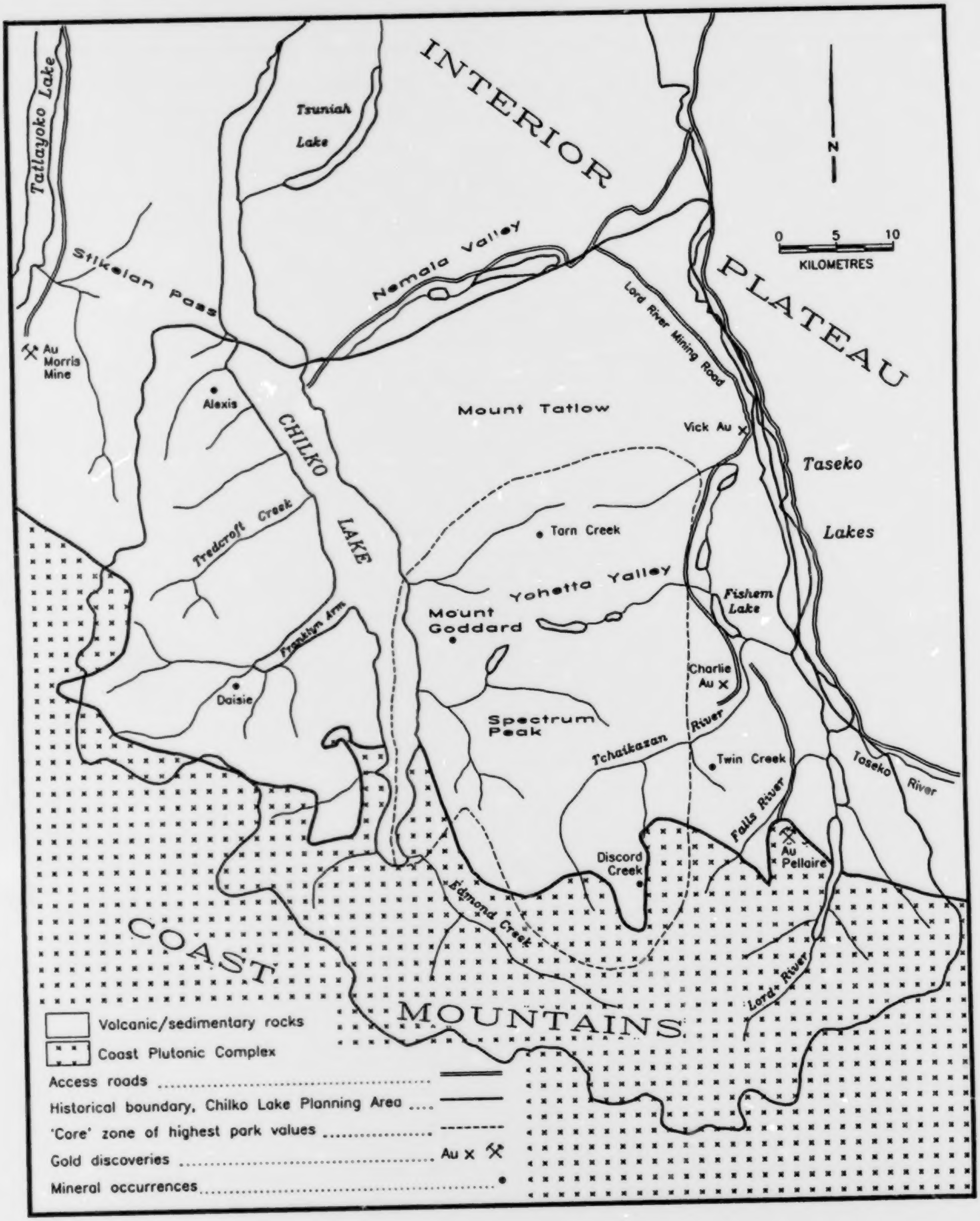
INTERIOR PLATEAU
COAST MOUNTAINS
N
0 5 10
KILOMETRES
Tatlayoko Lake
Tsuniah Lake
Stikelan Pass
Nemaia Valley
Au Morris Mine
Alexis
CHILKO LAKE
Mount Tatlow
Lord River Mining Road
Vick Au
Taseko Lakes
Torn Creek
Tredcroft Creek
Yohetta Valley
Fishem Lake
Mount Goddard
Franklyn Arm
Daisie
Charlie Au
Spectrum Peak
Tchaikazan River
Twin Creek
Taseko River
Falls River
Au Pellaire
Discord Creek
Edmond Creek
Lord River
Volcanic/sedimentary rocks
Coast Plutonic Complex
Access roads
Historical boundary, Chilko Lake Planning Area
'Core' zone of highest park values
Gold discoveries
Au
Mineral occurrences

Figure i. Chilko Lake Planning Area: location, geology and mineral occurrences.

presence of geochemical anomalies and geological/metallogenic trends that are favourable for mineral occurrences. Areas of either favourable geological or geochemical indicators suggest a low to moderate potential, but require further prospecting before this designation can be made with certainty. A limited area has been designated as having a low mineral potential.

Economic conditions often focus mineral exploration on certain commodities, such as the present emphasis on gold, and this is reflected in the designations of mineral potential. Currently, the greatest potential for an economic mineral discovery lies in locating precious metal vein deposits, however porphyry and possibly skarn deposits, if they contain sufficient gold, are also viable exploration targets. Volcanogenic massive sulphide deposits are not known in the area; however, there is a moderate potential for these occurrences in certain zones. Zones where the currently less attractive exploration targets, such as base metal porphyries, skarns and the massive sulphide environments are indicated, should be inventoried for possible future industry evaluation. Overall the Chilko Lake Planning Area has a sufficiently high mineral potential to warrant continued mineral exploration; further new mineral discoveries can be expected to follow.

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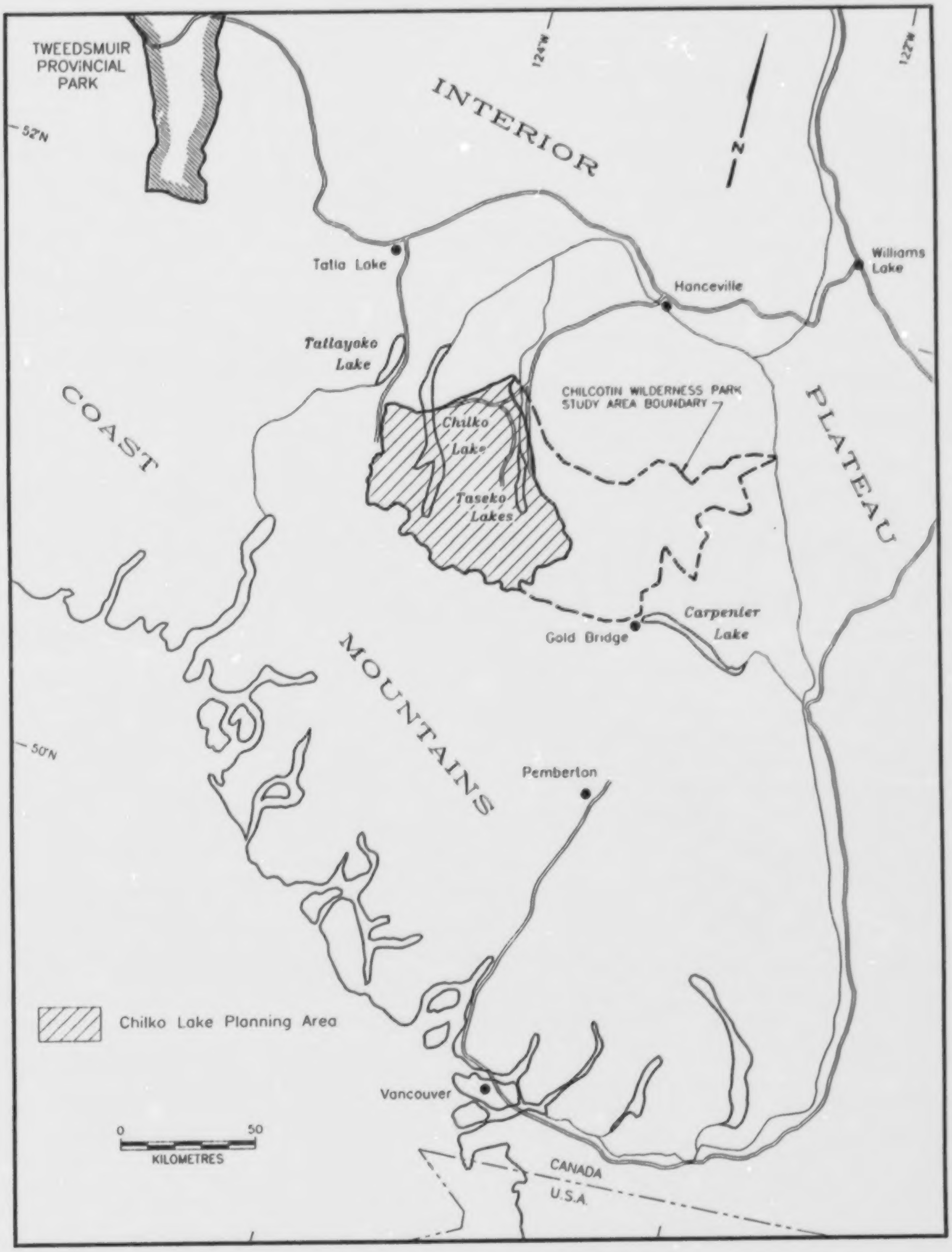

TWEEDSMUIR PROVINCIAL PARK
52°N
124°W
INTERIOR
N
122°W
Tatla Lake
Williams Lake
Hanceville
Tatlayoko Lake
COAST
CHILCOTIN WILDERNESS PARK STUDY AREA BOUNDARY
PLATEAU
Chilko Lake
Taseko Lakes
Carpenter Lake
Gold Bridge
MOUNTAINS
50°N
Pemberton
▨ Chilko Lake Planning Area
Vancouver
0
50
KILOMETRES
CANADA
U.S.A.

Figure 1. Chilko Lake Planning Area: location and access.

CHAPTER 1

INTRODUCTION

The Chilcotin Mountains of south-central British Columbia lie along the transition zone between the lofty peaks of the Coast Mountains and the undulating terrain of the Interior Plateau (Figure 1). Portions of this transition zone, such as the Bridge River and Tahtsa Lake areas, have proven high mineral values. In the vicinity of Chilko Lake the transition zone is an area of scenic beauty with high wildlife and recreation values that has been under long-term evaluation as a candidate for provincial park status (British Columbia Department of Recreation and Conservation, 1976). The mineral resources of the study area have never been evaluated in detail, however, preliminary studies (Northcote, 1982) indicated a significant mineral potential. This report is intended to objectively document this potential.

The Mineral Land-Use Subsection of the British Columbia Geological Survey Branch conducts field-oriented mineral resource assessments of areas where alienation of mineral rights is under consideration (such as in provincial parks). This work supports the Ministry of Energy, Mines and Petroleum Resources' policy to ensure that subsurface mineral resources are fully considered in the designation of surface land uses. For this reason the Geological Survey Branch has undertaken an assessment of the Chilko Lake Planning Area to determine its mineral potential. Known mineral occurrences have been evaluated and new mineral showings found. Zones with differing potential for the development of subsurface mineral resources have been identified and rated. This report presents the results of the first detailed field-oriented mineral resource assessment of a large provincial park study area undertaken in British Columbia.

MINERAL RESOURCE ASSESSMENTS

BACKGROUND

The increasing number of mineral resource assessments conducted in recent years throughout North America (for example, Cargill and Green, 1986) reflects the growing dilemma governments face in making land allocation decisions with limited information at hand. Initially, mineral resource assessments were aimed at quantifying potential national reserves of particular minerals, such as uranium reserve assessments conducted in the 1970s. These studies were soon applied to identifying the mineral potential of specific tracts of land of concern to Native organizations or to environmental groups and park planners. These regional evaluations were not intended to be applied to site-specific assessments, hence mineral potential was often not properly considered prior to land-use decisions. With the growing public demand for preserving wilderness in a pristine state, to the exclusion of future resource extraction, it is imperative that resource assessments be conducted prior to a land-use designation. Only in this way can a rational selection of boundaries be made.

In the United States, the *Wilderness Act* (1964) charged the Geological Survey and the Bureau of Mines with the responsibility for conducting mineral resource assessments on a planned and recurring basis in lands being considered for classification as wilderness. A synopsis of mineral surveys undertaken in about 800 individual areas comprising 45 million acres (18.2 million hectares) has been published by the U.S. Geological Survey (Marsh *et al.* 1984). Similarly, the Canadian National Parks policy, introduced in 1979, recognized the need for conducting assessments of nonrenewable natural resource potential prior to establishing any new national park. One such assessment conducted in the Bathurst Inlet area of the Northwest Territories identified zones of sufficiently high mineral potential to lead to the deferral of the decision to create a new National Park (Roscoe, 1986).

Mineral Deposit–Land Use (MDLU) maps were developed for "land use and regional socio-economic planning" in British Columbia in the early 1970s (McCartney *et al.*, 1974). These maps display mineral capability vis à vis the Canada Land Inventory System. Potential for future exploration (a measure of expected land use) was classified according to the size and number of known deposits and the regional geological environment. MDLU maps have been used widely in regional land-use planning in British Columbia, but are now out of date as new mineral discoveries have been made and new concepts of Cordilleran geology have been developed. Furthermore, at a scale of 1:250 000, MDLU maps are insufficiently detailed for determining precise boundaries for land use designations relative to mineral potential.

This paper documents a mineral resource assessment conducted in a relatively unexplored area of southern British Columbia. The Chilko Lake area was chosen for British Columbia's first formal mineral resource assessment of a land-use conflict area because: (1) it had a perceived moderate to high mineral potential based on limited available data, (2) it encompasses numerous scenic, recreational and wildlife habitat attributes that have long been thought worthy of protection within the provincial park system, and (3) it comprises an extensive area that could not be properly evaluated from existing literature. The end users of this report are anticipated to range from experienced exploration geologists to government and private sector land-use planners with a limited familiarity with the earth sciences. The following paragraphs therefore, attempt to clarify some of the basic concepts underlying this report.

SUBSURFACE VERSUS SURFACE RESOURCE ASSESSMENTS

Land-use designations should be made on the basis of a comparative evaluation of all types of resources in the area, with the final allocation going to the purpose perceived to offer the highest value use(s) of the land. Assessments of subsurface resources are significantly different from those for surficial resources, both in terms of data acquisition and the certainty of results obtained. Timber resources can be directly appraised and wildlife populations counted with some accuracy; game harvests can be tallied, scenic values directly described and recreational usage monitored and projected. These data provide a relatively reliable quantitative estimate of the value of the surficial resources involved.

Mineral resources, on the other hand, cannot be seen or directly measured without undertaking extensive and costly subsurface exploration. Surface geological, geochemical and geophysical surveys, plus an inventory of past exploration history and discoveries, provide the information necessary to compile a mineral resource assessment. However, even armed with this information, subsurface resources still cannot be directly quantified. The transformation of these data into an estimate of subsurface resource potential must always involve a subjective, qualitative component. Furthermore, to provide a comparative value against surface resources, mineral evaluations require an economic and technological feasibility assessment founded upon numerous assumptions of future conditions. The final values attributed to the mineral potential of an area are much less certain and more difficult to verify than evaluations of surficial resources.

This is not to infer that mineral resource assessments are not worthwhile ventures. It is of critical importance that the purpose of the study is clearly understood, and that the end users and the expected or acceptable end products are correctly identified before the assessment method to be used can be assigned (Singer and Mosier, 1981). The aim of all mineral potential studies by governments is to identify areas thought more likely to contain ore deposits, but not necessarily to locate and evaluate specific deposits. Where sufficient data exist, further statistical assessments can be made to attempt to quantify the magnitude and value of minerals in the ground. Assessments yielding relative values of areas in terms of present (known) and future (undiscovered) resources provide the most useful information for government planning and land-use decisions (Findlay, 1982).

Even though absolute values of mineral resources cannot be accurately provided to a planning process, the geographic extent and mineral resource potential of an area in conflict can be identified so that reasoned judgments as to the best use of the land can be made. Such studies are also of practical use to the exploration industry (Findlay and Sangster, 1982), providing guidelines and possibly targets for more detailed exploration. It is the prerogative of the industry to undertake the expensive and high risk venture of locating and developing specific mineral deposits.

STYLES OF MINERAL RESOURCE ASSESSMENTS

Mineral resource assessments generally fall into two broad overlapping categories relative to the output provided: quantitative and qualitative (Findlay, 1982). Quantitative estimates normally rely on statistical manipulations on a wealth of data from mines and documented mineral occurrences in a well-explored region to infer the types and amounts of mineral resources yet to be discovered there (for example, Drew *et al.*, 1986). Data from well-explored areas can be extrapolated to lesser known regions of analogous geological characteristics to yield expectations on the mineral resources contained in the underexplored area. These studies tend to cover areas large enough or sufficiently well mineralized to provide enough data for meaningful statistical evaluations (*e.g.*, Alaska, Singer and Ovenshine, 1979; northwestern Canada, Barry and Freyman, 1970). However, experience has shown that for most areas the existing database and interpretive methodologies are inadequate to support such rigorous analyses (Hutchison, 1986; Harris and Agterberg, 1981).

In contrast, qualitative assessments attempt to fit known geological characteristics of an area into mineral deposit models to identify the relative potential for certain deposit types. Greater confidence in the assessment can be achieved if the deposit model used occurs in adjacent areas of similar geology. This style of mineral resource assessment is suitable for application to specific areas in remote locations that have undergone little intensive exploration. These are often the areas that have characteristics appealing to wilderness preservationists. The Geological Survey of Canada has used such an approach in a variety of land-use studies in Northern Canada (Geological Survey of Canada, 1980), including evaluations of proposed national parks (for example, Geological Survey of Canada, 1981a, b; Roscoe, 1984; Jackson and Sangster, 1987).

Other attempts (*e.g.*, Voelker *et al.*, 1979) have been made to use qualitative decisions to rate the favourability of various factors for the occurrence of mineral deposits; these factors have then been combined in a final rating of overall mineral potential. This approach developed a semiquantitative measure of mineral potential and was determined to be more useful to land-use managers than purely objective geoscientific evaluations with no value judgment attached. Assessments of this nature, that bridge the gap between qualitative and quantitative studies, are applicable to areas with recently updated mineral potential surveys but that still lack quantified measurements of resources in the ground.

Assessments conducted in under-explored areas provide interpretations of geologic history and indications of mineralization. These data can then be compared with well-explored areas of analagous geologic history and well-documented mineralization that serve as "training tracts" to characterize the mineral potential of the assessment area. Training tracts are of greatest value if located nearby but outside the study area. Quantitative statistical assessments make extensive use of training tracts (Singer and Mosier, 1981), however, qualitative evaluations also make effective use of analogous regions (Roscoe, 1984).

Similarly, mineral deposit models provide the standard against which the geological features of an assessment area can be tested. Deposit models are conceptual frameworks outlining ideas on the genesis of ore deposits. The models are developed from the regional geologic environments and local characteristics (geological, geochemical, *etc.*) of a large number of well-documented deposits of the same type, often from many localities around the world. They commonly form the basis of industry exploration programs as they provide the diagnostic features or clues to be sought in exploring a region, or a locale, for new deposits. A variety of deposit models (Eckstrand, 1984; Cox and Singer, 1986) are used widely in mineral resource assessments (Geological Survey of Canada, 1980; Findlay *et al.*, 1981).

	MINERAL ENDOWMENT	
Currently Uneconomic to Recover	Identified Presently Uneconomic RESOURCES	Unidentified Presently Uneconomic RESOURCES
Recoverable under present economic/ technical conditions	RESERVES	Unidentified Presently Economic RESOURCES
	IDENTIFIED	UNDISCOVERED

Decreasing certainty of existence →

↑ Decreasing feasibility of economic recovery

Figure 2: Classification of mineral endowment, resources and reserves (adapted from Zwartendyk, 1972; *see also* McKelvey, 1973)

Reserves versus Resources

A distinction must be made between the terms "resources" and "reserves". Resources refer to mineral concentrations that could conceivably be mined in the future, given that certain economic, technological and transportation conditions are met. Resources range from known deposits (with a defined size, i.e. tonnage and grade) to speculated (undiscovered) deposits. Reserves are those portions of mineral resources that have been measured with a degree of certainty and are thought to be economically mineable at current commodity prices and operating costs. Thorough discussions of these terms are provided in Zwartendyk (1972), McKelvey (1973) and Brobst and Pratt (1973).

The term "mineral endowment" is often applied to all mineral occurrences regardless of size and includes mineral accumulations that are too small to ever be exploited. Figure 2, an adaptation of the "McKelvey box", graphically displays the relationships in this classification.

Mineral Potential

Mineral potential is a characteristic attributed to a geological terrane that describes the probability for the presence of mineral deposits, including both resources and reserves. Mineral potential assignments are made by determining how well the available geological, geochemical and geophysical data apply to the mineral deposit models discussed above. Factors affecting economic viability of the mineral deposits are not considered in this definition.

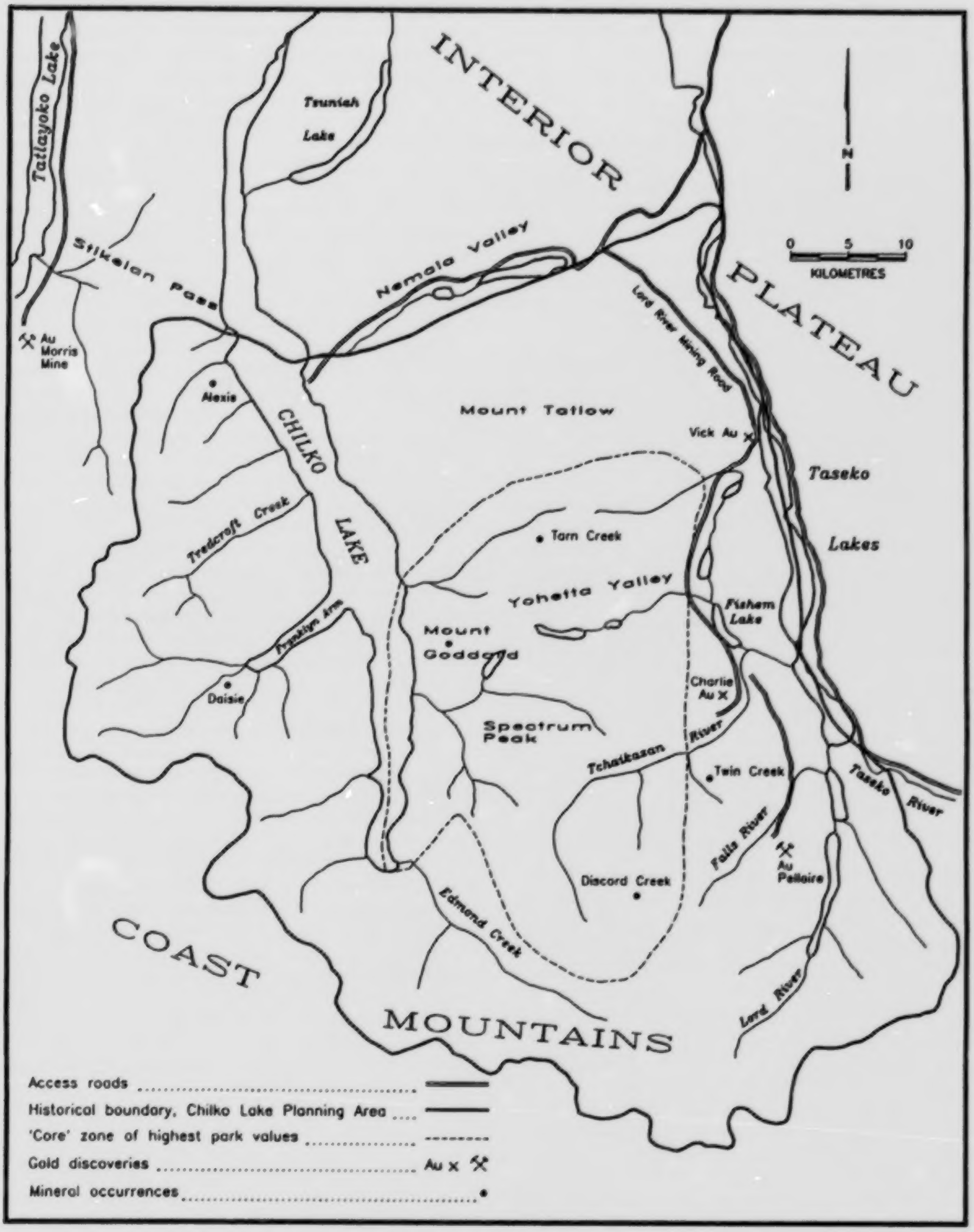
As a final note to land-use planners not familiar with the nature of the mineral exploration industry, it must be stressed that statements about mineral potential, resources or reserves are estimates and not hard and fast statements of fact, even in operating mines. These terms are dynamic and variable entities that reflect the technical and high-risk economic nature of the mineral exploration and development industry. Mineral exploration and mining are characteristically intermittent and repetitive processes; mines thought to be exhausted are often revived as a result of changing economic conditions, including the development of new infrastructure, and by new advances in mining technology and geological concepts. There are many notable examples of revitalization of old mining districts in British Columbia, including Copper Mountain, the Hedley, Greenwood and Stewart mining camps and the Britannia mine to name but a few. Planners must not make false assumptions that if mineral prospects are not economic today, then they will remain uneconomic in the future. It is of prime importance that assessments clearly establish the potential for mineral resources and reserves so that estimates of their value may be tallied and inventoried for future use in land-use planning.

Clearly, mineral potential is not related to scenic beauty or recreational values. The search for new mines in the province follows zones that contain attributes of mineral deposits whether they be in scenic alpine meadows or lowland forests. Isolated areas of natural wilderness are often cited as possessing special values to outdoors enthusiasts, in part due to their remote and relatively inacessible character. These very characteristics are valued by a prospector as an indication of greater potential for new mineral discoveries as they have generally seen less exploration than elsewhere. Many parts of the province currently indicated to have a moderate or low mineral potential will be re-evaluated and upgraded to a higher potential classification as further detailed geological surveys are conducted and new discoveries are made.

CHILKO LAKE PLANNING AREA

During the mid-1970s studies were undertaken by the British Columbia Parks Branch to evaluate the potential park values of a large portion of the Chilcotin Mountains (British Columbia Department of Recreation and Conservation, 1976). An inventory was taken of recreation and conservation values. An interagency dialogue was held on all natural resource values. The initial study region extended from Tweedsmuir Park in the north to Carpenter Lake and the historic mining community of Gold Bridge in the south (Figure 1). Within this region an area from west of Chilko Lake to Carpenter Lake received further study. The high mineral and forestry potential determined between Taseko and Carpenter Lakes led to the exclusion of that area from future park studies. However the Chilko to Taseko Lakes area, and specifically a zone centred on the Tchaikazan valley (Plate 1), was identified as possessing "features and values of provincial significance . . . which were not represented elsewhere in the provincial park system" (British Columbia Ministry of Lands, Parks, and Housing, 1982). As a result, detailed evaluations continued in this area in 1981, culminating in a selection of alternative park and recreation area designations being recommended. A core area centred on the Tchaikazan and Yohetta valleys and extending west to Chilko Lake was deemed to have the highest park values (Figure 3).

Literature studies by the British Columbia Ministry of Energy, Mines and Petroleum Resources at this time (Northcote, 1982) showed that the geological database available for the area was out of date and insufficiently detailed for



Tatlayoko Lake
Tsuniah Lake
INTERIOR
PLATEAU
N
0 5 10 KILOMETRES
Stikelan Pass
Nemaia Valley
Lord River Mining Road
Au Morris Mine
Alexis
CHILKO LAKE
Mount Tatlow
Vick Au
Taseko Lakes
Tredcroft Creek
Tarn Creek
Yohetta Valley
Fishem Lake
Franklyn Arm
Mount Goddard
Daisie
Charlie Au
Spectrum Peak
Tchaikazan River
Twin Creek
Taseko River
Falls River
Au Pellaire
Discord Creek
Edmond Creek
COAST
MOUNTAINS
Lord River
Access roads
Historical boundary, Chilko Lake Planning Area
'Core' zone of highest park values
Gold discoveries Au x ⚒
Mineral occurrences •

Figure 3. Physiography of the Chilko Lake Planning Area.

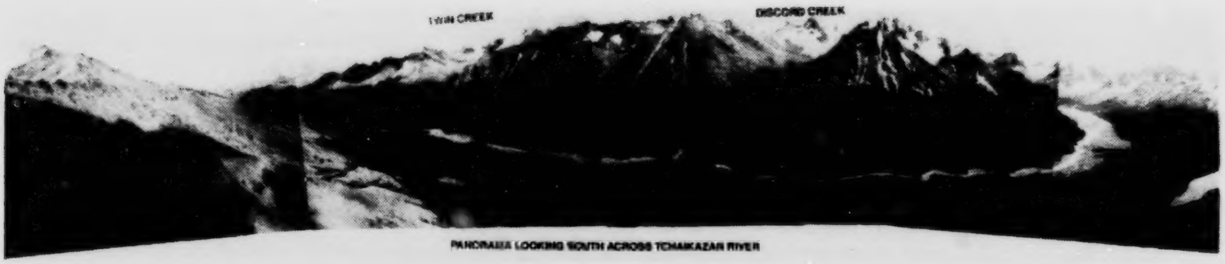


Plate 1. The Tchaikazan valley. Panorama looking south across the Tchaikazan River. The Tchaikazan River lies at 1515 metres (5000 feet) above sea level; the foreground peaks rise to 3000 metres (10 000 feet).

informed land-use decisions. Furthermore, no systematic industry exploration of the area had taken place, largely because of its inaccessability, although modern exploration surveys conducted in the southwestern portion of the area after 1980 resulted in the discovery of new mineral occurrences. Several geologic environments were identified as favourable hosts for a variety of mineral deposits (Northcote 1982, Northcote *et al.*, 1983). It became clear that a detailed mineral resource assessment of the area must be conducted prior to any lands being alienated from mining or mineral exploration. This report details the results of a two-year field-oriented mineral resource assessment initiated in 1985 to identify the mineral potential of the key areas within the Chilko Lake Planning Area.

HISTORY AND ACCESS

The Chilko Lake area has remained isolated from substantial human activity largely due to its remoteness and a long history of poor access. Native peoples have long used the valleys and lakes for hunting, grazing and fishing; however, settlement has never been extensive. Consequently mineral explorationists have been a prime factor in developing access to the area.

Prospectors first explored here in the early 1900s when the Morris mine was discovered 12 kilometres west of Chilko Lake. Copper and zinc skarn occurrences were located in this period near the head of Franklyn Arm on Chilko Lake. When Dolmage (1925) undertook the first geological survey specific to the Chilko Lake area in 1924 he concluded that "the geology of the region is such that the occurrence of mineral deposits may be expected" (p.68A).

Mineral discoveries and development of access east of Taseko Lakes progressed much more rapidly than within the planning area itself. However, gold-bearing veins were discovered on the periphery of this access network, within the current study area, at the Vick showings near the head of Taseko Lakes in 1932, at the Pellaire occurrence (also referred to as Hi-Do or Lord River gold mine) in 1936, and at the Charlie occurrence in the Tchaikazan valley in 1946 (Warren, 1947). It was not until 1980 that a road was developed west of Taseko Lakes to provide direct access to these deposits. The majority of the study area remains inaccessible by roads and, as a result, has an exploration history markedly different from adjacent areas. Most of the area has only undergone reconnaissance-style mineral exploration; more comprehensive exploration programs have been restricted to those small portions of the study area where access has been developed.

In 1939 and 1957, reconnaissance geological mapping was conducted in the Tatlayoko – Chilko – Taseko lakes area in support of potential hydro-electric power schemes (Holland and Nasmith, 1957). Tunnels were proposed in a number of locations to divert water through the Coast Range from the Chilko-Taseko lakes drainage area into Tatlayoko Lake and the Bishop River, both of which flow into Bute Inlet. No recent work has been conducted on this project.

Surface access to the area is currently gained from Hanceville on Highway 20 west of Williams Lake (Figures 1, 3). From this point a gravel road extends to the Nemaia valley and the eastern shore of Chilko Lake. The Lord River Mining road departs the Nemaia road at Elkin Creek and follows southwards to the Tchaikazan and Falls rivers. The bridge crossing the Tchaikazan was washed out in 1984 and has been temporarily rebuilt only during periods of recent active exploration at the Pellaire gold occurrence. A rough dirt road leads a short distance into the Yohetta valley. A gravel airstrip is located at the south end of Fishem Lake.

To the west of Chilko Lake, an access road extends to within 10 kilometres of the study area. This road leaves Highway 20 at Tatla Lake and extends east of Tatlayoko Lake to the Morris mine (Figure 3). Road access to the west shore of Chilko Lake could be established through Stikelan Pass.

Helicopter bases serving the area are located in Pemberton(130 kilometres to the south), Williams Lake(150 kilometres to the east), and at Bluff Lake (80 kilometres to the northwest).

PHYSIOGRAPHY AND RESOURCES

The Chilko Lake Planning Area contains some 2370 square kilometres (237 000 hectares) situated approximately 230 kilometres north of Vancouver and 150 kilometres southwest of Williams Lake. The area covers the transition between the Coast Range to the south and west and the Interior Plateau to the north and east (see frontispiece). Rugged mountainous terrain with numerous alpine glaciers and deeply incised U-shaped valleys predominate in and adjacent to the Coast Mountains. Elevations range from peaks over 3200 metres (10 500 feet) to 1220 metres (4000 feet) in valley bottoms. The ridges become somewhat

Plate 2. Chilko Lake, looking south into the Coast Mountains. Franklyn Arm, trending west, is 9 kilometres long (8 kilometres are visible).

rounded and the valleys broader to the northeast, with the exception of Mount Tatlow, a 3060-metre (10 000 foot) alpine peak near the northern boundary of the area.

A series of east and northeast-trending valleys transects the mountains. Chilko Lake (Plate 2) extends northerly through the entire landscape for more than 60 kilometres and is the highest major lake in British Columbia at an elevation of 1172 metres (3846 feet). Maximum depth of the lake is 365 metres (1200 feet), making the Chilko valley an exceptional feature cutting across the regional trends in these mountains. The Taseko Lakes – Lord River drainage system forms a similar northerly trending valley on the eastern border of the area.

Bedrock exposure in the area is excellent on the higher peaks and ridges, although is often inaccessible in the steeper glaciated terrain. Extensive talus masks the lower slopes. Glacial deposits and thick vegetation below the 1600-metre (5250 feet) level obscure most rock outcrop, hence geological contacts must be interpreted across valleys. Exploration at lower elevations must rely on geochemical or geophysical methods, or on prospecting creek beds that expose bedrock.

Forest resources of the area are not extensive. Stands of merchantable timber may be present at low elevations in the broad valleys as on the west shore of Chilko Lake. A variety of wildlife inhabit the area. Moose, deer, and black bear are seen at lower elevations and mountain goat are common in the uplands. California bighorn sheep and grizzly bear are also present. Numerous smaller fur-bearing animals, such as marmots, pikas and rabbits, and a wide variety of birdlife are seen regularly. The Chilko and Taseko drainage systems support a sizeable fishery resource, including sockeye and chinook salmon, rainbow trout, whitefish, and Dolly Varden char. Alpine flowers are abundant in many meadows. These features combine to offer numerous recreational activities to outdoor enthusiasts including mountain climbing, backpacking, fishing, hunting, canoeing or horseback riding. Guide-outfitters and trappers also use the area. Few archaeological sites have been identified in the area, however, it is expected that a large number of undisturbed sites are present, particularly in the Yohetta valley and near Mount Tatlow (British Columbia Ministry of Lands, Parks and Housing, 1982).

SCOPE OF CURRENT ASSESSMENT

Fieldwork for this project was undertaken during July and August of 1985 and 1986. In each season, a crew of four, operating largely from helicopter-supported mobile fly camps, conducted geological mapping, geochemical stream-sediment sampling and lithogeochemical (rock) sampling. Initially work was concentrated in the core area of highest park values between Taseko and Chilko lakes and was expanded to the west of Chilko Lake in 1986. Stream-sediment sampling covered an area of approximately 1800 square kilometres, however, mapping and lithogeochemical sampling were concentrated in areas of volcanic and sedimentary bedrock. The entire planning area has not been covered by these surveys, but the area of prime interest to park planners has been evaluated as effectively as the time and resources available to the project would allow.

The following comments are provided as brief explanations for readers unfamiliar with geological surveys or mineral exploration procedures. Geologic mapping of an area at a minimum scale of 1:50 000 is generally required to identify all rock units and describe their character, to determine relative or absolute ages of units, and to define the structural features (faults, folds etc.) that have deformed the rocks. This allows interpretation of the geologic history of the area. Mineralizing events are distinct episodes in this history and identifying when, where and why these episodes occurred is a major step in conducting a mineral resource assessment. With this information the mineral deposit models referred to in an earlier section can be fitted to portions of the geologic history and areas of greater mineral potential can be defined.

An orebody is generally a relatively small feature, rarely exceeding a few hectares in extent, however, the associated peripheral rock alteration provides clues to the presence of the ore over a much broader area. Rock samples from all sites with even weak indications of the presence of mineralization are analyzed in an effort to detect anomalously high concentrations of metals. These samples provide site-specific information only and samples of stream sediments are also analyzed to determine the metal content of sediments derived from a larger drainage basin. Stream sediment collection requires considerable time and effort, however, it provides direct guidance for further prospecting. This was well demonstrated in this project as an arsenic-bearing vein system was discovered in 1986 while following up an anomalously high arsenic value determined in a sediment sample collected in 1985.

Airborne geophysical surveys are another component of a regional mineral resource evaluation, as clues to the nature of orebodies, rock types and structural features may be revealed, even beneath the extensive cover of talus and glacial drift. Such surveys are expensive and were beyond the resources available to this assessment.

This study followed the pattern outlined above and it must be appreciated that it is impossible to gain first-hand knowledge of every ridge and valley in such a large area of rugged terrain. A specific area can be traversed and reasonably well documented while working on foot from each campsite, however geologic boundaries and other features must be interpreted between these areas. Furthermore, indications of an ore deposit may be clearly visible from a distance, such as from a helicopter, or may only become apparent at close range. New mineral showings at both ends of this spectrum were found during this survey. These new discoveries serve to emphasize the fact that this paper is not intended as a definitive discussion of the mineral occurrences in the Chilko-Taseko lakes area. Many ridges and valleys have not been traversed and wide expanses of bedrock are hidden beneath talus or glacial drift. Prospecting here is akin to searching for needles in haystacks that are partially inaccessible and largely obscured. The intent of this paper is to confirm that needles (mineral resources) are indeed present in the Chilko Lake Planning Area and to suggest which haystacks (geologic features; zones of higher potential) are most likely to yield successful exploration results.

ACKNOWLEDGMENTS

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Competent and cheerful field assistance was provided by Kerry Curtis, John Bradford, Paul Fagerlund, Dugald Dunlop and Alan Vichert. Tom Bugg of Highland Helicopters and Eldon Talbot of Pemberton Helicopters are thanked for experienced helicopter and logistic support in the field. Landsat imagery of portions of the area was kindly provided by Paul Hawkins, Suncor Inc., Calgary. Identification of fossils collected in this study was completed by various members of the Geological Survey of Canada including Howard Tipper, Terry Poulton, Arthur Sweet and the late Dr. J.A. Jeletzky.

This project is, in part, a contribution to the Canada/British Columbia Mineral Development Agreement 1985–1990.

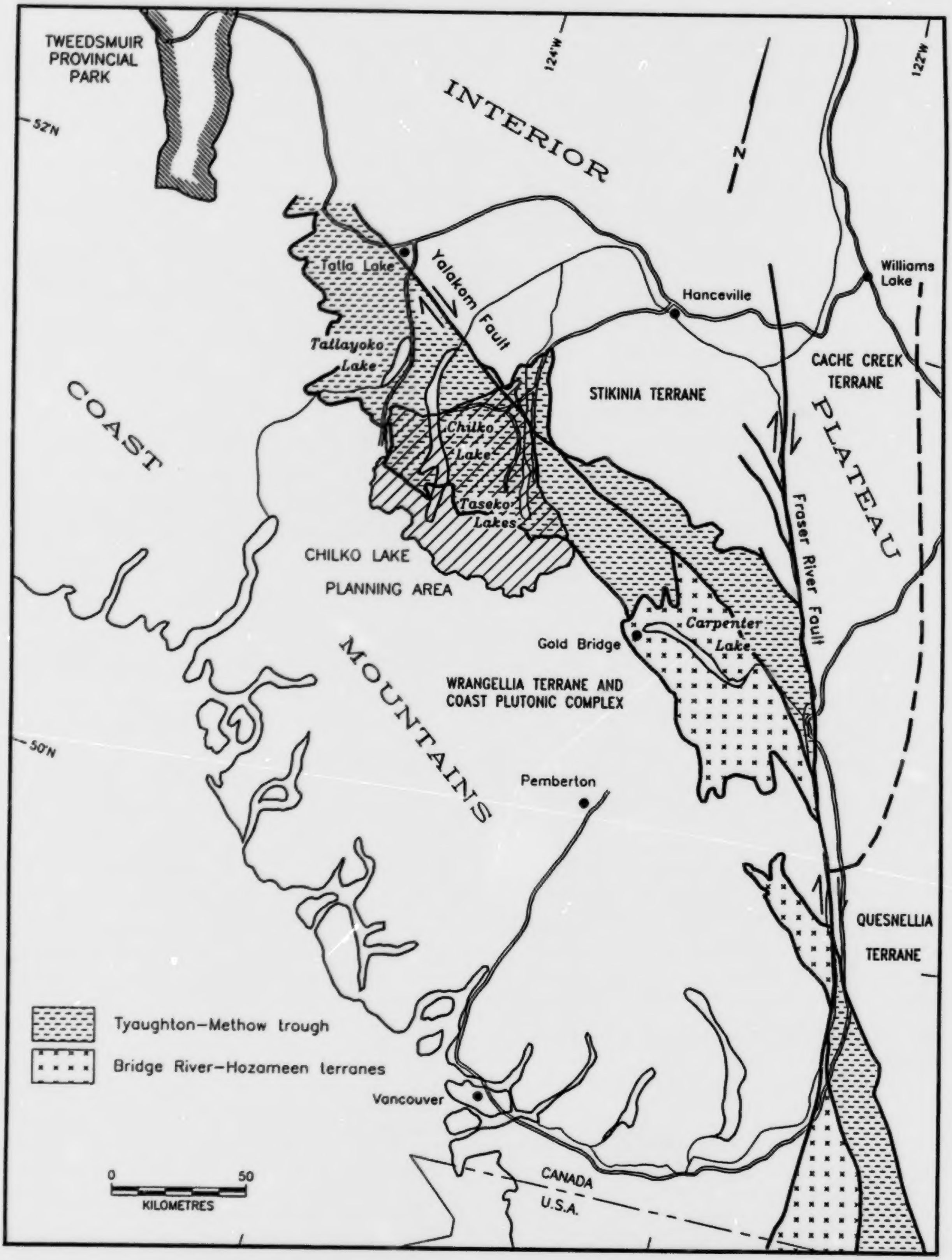
TWEEDSMUIR PROVINCIAL PARK
52°N
124°W
122°W
N
INTERIOR
PLATEAU
Tatla Lake
Yalakom Fault
Tatlayoko Lake
Hanceville
Williams Lake
CACHE CREEK TERRANE
STIKINIA TERRANE
COAST
Chilko Lake
Taseko Lakes
CHILKO LAKE PLANNING AREA
Fraser River Fault
Carpenter Lake
Gold Bridge
WRANGELLIA TERRANE AND COAST PLUTONIC COMPLEX
MOUNTAINS
50°N
Pemberton
QUESNELLIA TERRANE
Tyaughton–Methow trough
Bridge River–Hozameen terranes
Vancouver
0
50
KILOMETRES
CANADA
U.S.A.

Figure 4. Location of the Chilko Lake Planning Area with respect to tectonostratigraphic terranes.

GEOLOGIC SETTING

INTRODUCTION: REGIONAL ENVIRONMENT

Recent syntheses of Canadian Cordilleran geology indicate that much of British Columbia is constructed of a collage of distinct geological terranes that formed as discrete crustal fragments well to the west of the ancient North American continent. These allochthonous[1] terranes collided with one another to form large composite terranes which in turn coalesced, in stages, with the western margin of North America. This accretion of terranes onto North America was a complex process spanning over 120 million years (Monger *et al.*, 1982). Individual terranes are identified by a characteristic stratigraphy that records the environment of formation of the rock units. Terranes have been dismembered and wrenched apart along major fault zones during collisions occurring at oblique angles with the continental landmass, hence many terrane boundaries are represented by extensive fault or suture zones. Younger faults, related to continuing plate tectonic adjustments, cut and further offset portions of the accreted terranes (*e.g.*, Fraser River fault zone).

During the mid-Cretaceous period (approximately 100 million years ago) a composite terrane collided with older terranes previously accreted to North America. This collision took place while the North American plate moved relatively westward into various Pacific plates and while Pacific oceanic crust was being subducted[2] beneath the coast of North America. Heat generated by this subduction process resulted in uplift and emplacement of the granitic rocks of the Coast plutonic complex. Immediately prior to this mid-Cretaceous collision an elongate basin, referred to as the Tyaughton-Methow basin (the Canadian portion being the Tyaughton trough; Figure 4) developed between the continental landmass and an offshore island arc. Volcanism within the island arc, similar to that seen around the Pacific today, was another result of the collision-subduction process. Sedimentary detritus collected in the centre of the basin as it was eroded from the bordering highlands; this deposition ceased when the basin was later uplifted during the same mid-Cretaceous collision. Subsequent uplift of the Coast Mountains led to erosion of much of the volcanic island chain developed on the western margin of the basin; isolated remnants of the volcanic rocks have been preserved as pendants within the Coast Range batholith. Rocks deposited in the basin were subsequently wrenched apart along collision-induced fault zones with displacements along these faults exceeding 100 kilometres (Kleinspehn, 1985; Tipper, 1969). As a result, rocks of this basin overlap the junction of a number of accreted terranes in southwestern British Columbia (Figure 4).

The Chilko Lake Planning Area is situated on the southwestern flank of what once was the Tyaughton trough, in an area where volcanic rocks predominate over sedimentary rocks. The area records a predominantly Early Cretaceous volcanic island arc environment transitional to a marine sedimentary basin environment. Influxes of externally derived quartz-rich sedimentary material reflect the uplift and erosion of adjacent land masses. Intrusive rocks of the Coast plutonic complex truncate the sedimentary and volcanic sequences across the southern and western parts of the area. These granitic intrusions have uplifted the older volcanic island arc and exposed it to erosion. Subsidiary splays from major fault zones extend across the Chilko Lake area; lateral displacement along one of these structures, the Tchaikazan fault, has been estimated at 30 kilometres (Tipper, 1969).

Volcanic rocks of a similar age are found in various parts of southwestern British Columbia, including near Squamish and Harrison Lake. These rocks may once have formed a continuous volcanic island arc that has since been dismembered and largely removed by faulting, uplift and erosion. The similarities between these pendants of volcanic rocks are of significance relative to the mineral potential of the Chilko Lake area because the Britannia mine near Squamish, and numerous gold occurrences near Harrison Lake, occur in these rocks. Mineralization at Britannia is thought to be related to the volcanism and to have developed simultaneously with the enclosing rocks, hence there is potential for similar deposits wherever these rocks occur. The large fault zones cutting through the Chilko Lake Planning Area may also be related to the major faults that exert controls on precious metal vein mineralization in the Bridge River camp, 80 kilometres to the southeast. This area contains numerous old gold mines (Bralorne, Pioneer) and has produced more gold than any other district in British Columbia. Finally, the variety of intrusive rocks and associated mineralization present in the area indicate that the environment for porphyry copper-gold deposits, known immediately to the east at Fish Lake and 70 kilometres east at Poison Mountain, is also present.

The earliest surveys indicated that the geological features, now within the Chilko Lake Planning Area, record a variety of dynamic geologic processes and have potential for a variety of mineral deposit types. The increased geologic knowledge gained in this study has only served to confirm this conclusion through direct observation and indirect comparisons with similar geological environments elsewhere in southwestern British Columbia.

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[1] allochthonous: rocks that have been moved a long distance from their original place of deposition by some tectonic process.

[2] subduction: the process of one crustal block descending beneath another, by folding, faulting or both (Monger *et al.*, 1982).

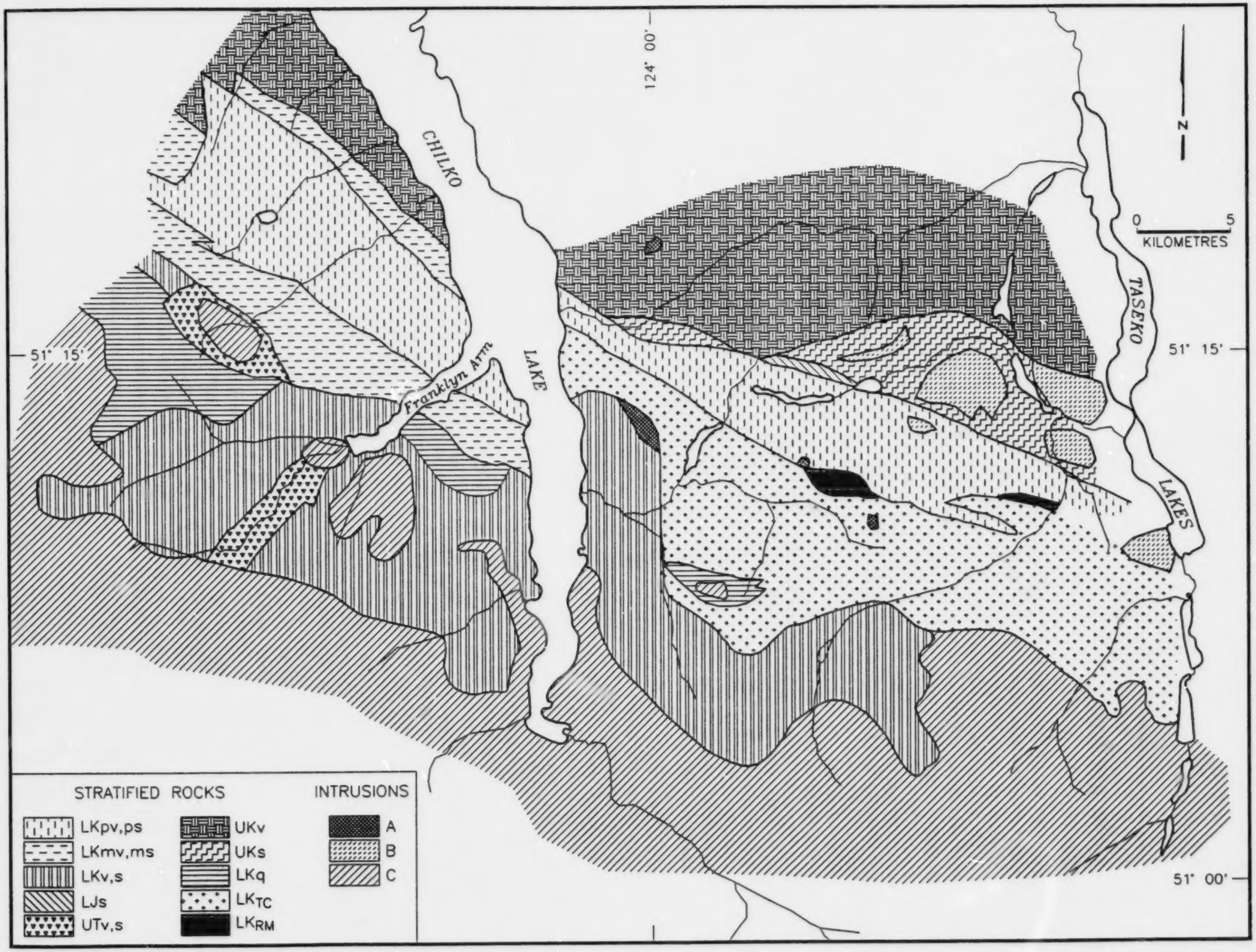

124° 00'
N
0
5
KILOMETRES
CHILKO
LAKE
TASEKO
LAKES
Franklyn Arm
51° 15'
51° 15'
51° 00'
STRATIFIED ROCKS
LKpv,ps
LKmv,ms
LKv,s
LJs
UTv,s
UKv
UKs
LKq
LKTC
LKRM
INTRUSIONS
A
B
C

Figure 6. Generalized distribution of map units in the Chilko Lake Planning Area.

LEGEND

SEDIMENTARY AND VOLCANIC ROCKS

QUATERNARY

Pleistocene

Q Till, gravel, sand, alluvium

INTRUSIVE ROCKS (AGES UNCERTAIN)

A Diorite stocks, dikes: hornblende diorite

B Felsites: feldspar and biotite feldspar prophyry

C Coast plutonic complex: granodiorite, quartz diorite.

UPPER CRETACEOUS

Cenomanian(?) and younger

UK_v Andesitic to baslatic pyroclastics, flows and volcanic sediments; minor greywacke and argillite.

UK_s Argillite, quartz sandstone, arkose, conglomerate; minor volcanic flows and tuffs.

LOWER CRETACEOUS

Albian and Hauterivian

LK_q Quartzose sandstone, chert-pebble conglomerate, argillite, minor siltstone.

LK_{TC} Dacitic to basaltic pyroclastics, flows, breccias, and volcanic sediments; argillite, siltstone, sandstone and conglomerate.

Barremian and Hauterivian

LK_{RM} Black argillite, siltstone, sandstone, minor tuffs and flows.

LK_{pv} Purple andesitic pyroclastics, minor flows, purple greywacke and conglomerate; LK_{ps} — dominantly sediments.

LK_{mv} Rhyolitic to basaltic pyroclastics and flows, volcanic sediments; LK_{ms} dominantly quartzose sandstone, greywacke, argillite.

$LK_{v,s}$ Rhyolitic to basaltic pyroclastics and flows, volcanic sediments, minor siltstone and greywacke; LK_s — dominantly sediments.

LOWER JURASSIC

LJ_s Argillite, siltstone, conglomerate, impure limestone.

TRIASSIC

UT Andesitic to basaltic flows and tuffs, argillite, siltstone, limestone.

PREVIOUS WORK

The geology surrounding Chilko Lake was first described by Bateman (1914) after an exploratory trip from Lillooet to Chilko Lake. He reported minor antimony mineralization on the west shore of Chilko Lake. Dolmage (1925) mapped the Chilko – Taseko lakes area in 1924 and broadly divided the stratified rocks into Triassic and Cretaceous formations. Copper-tungsten-bearing skarns and small gold-bearing quartz veins, all near the head of Franklyn Arm, were recorded at this time.

More recently, the Mesozoic volcanic and sedimentary stratigraphy of the Mount Waddington (92N) and Taseko Lakes (92O) map sheets has been mapped by Tipper (1969, 1978; compiled in Roddick and Tipper, 1985). Jeletzky and Tipper (1968) described the faunal stratigraphy and depositional environments in the Taseko Lakes map area. They proposed the name 'Tyaughton Trough' for the elongate basin noted above and in Figure 4. The Ministry of Energy, Mines, and Petroleum Resources is currently conducting a 1:50 000-scale geological mapping and mineral potential evaluation of the Taseko – Bridge River area, including much of the Mesozoic strata in the Tyaughton trough (Glover and Schiarizza, 1987; Glover *et al.*, 1988).

Preliminary results of work conducted in this survey, including 1:50 000-scale geological maps have also been published (McLaren, 1986a, b; 1987a, b).

Prospecting and industry exploration of the area has been conducted intermittently since the 1920s. Relevant exploration histories will be described more fully in Chapter 4.

LOCAL GEOLOGY

Figure 5 (in pocket) presents a 1:100 000-scale geological compilation of the area mapped in this project. Approximately 1800 square kilometres were covered by the various phases of this study; geological mapping varied in detail depending on accessibilty, complexity of the geology, and indications of mineralization. Some data from assessment reports have been incorporated. Stratigraphic and structural relationships north of Long Valley and in the northwestern corner of the map area are somewhat speculative as only a few reconnaissance traverses were completed in these areas. The distribution of map units is generalized in Figure 6.

STRATIGRAPHIC CORRELATIONS

The Chilko Lake Planning Area is underlain mainly by Lower Cretaceous volcanic and sedimentary strata, with limited exposures of Upper Triassic and Lower Jurassic lithologies. The Cretaceous strata were previously correlated with rocks of the Relay Mountain and Taylor Creek groups that accumulated in the Tyaughton trough, and with the overlying Kingsvale Group (Tipper, 1978). The preponderance of volcanic lithologies west of Taseko Lakes, and specifically those interbedded with Lower Cretaceous sedimentary strata between Chilko and Taseko lakes, has long posed a problem in correlating these rocks with the coeval, dominantly sedimentary rocks that accumulated in the axial regions of the Tyaughton trough to the southeast. Mapping in this project illustrates that the Chilko Lake region lies along the southwest flank of the trough where clastic basinal sediments interfingered with volcanic island arc lithologies during the Early Cretaceous. Strata equivalent to the Jurassic section of the Tyaughton trough (the lower portion of the Relay Mountain Group) are unknown within the study area. Lower Cretaceous strata unconformably overly Upper Triassic rocks in one location; elsewhere the base of the Cretaceous section is faulted or intruded. Whether the Jurassic rocks were eroded or were simply not deposited this far to the southwest is unknown.

Figure 7 outlines the stratigraphic relationships of rock units in the study area and Table 1 provides correlations with the results of other workers in southwestern British Columbia. Two columns are shown in Figure 7, representing two coeval depositional environments on each side of Chilko Lake. Upper Triassic volcanic and sedimentary strata ($UT_{s,v}$), including some fossiliferous limestone, occur in two fault-bounded blocks west of the lake. These appear to be correlative with the Mount Moore volcanics described by Rusmore and Woodsworth (1988) immediately west of the study area. Cretaceous strata comprise volcanic and sedimentary rocks represented by a lower Hauterivian marine unit ($LK_{v,s}$) overlain by a transitional marine ($LK_{mv,ms}$) to

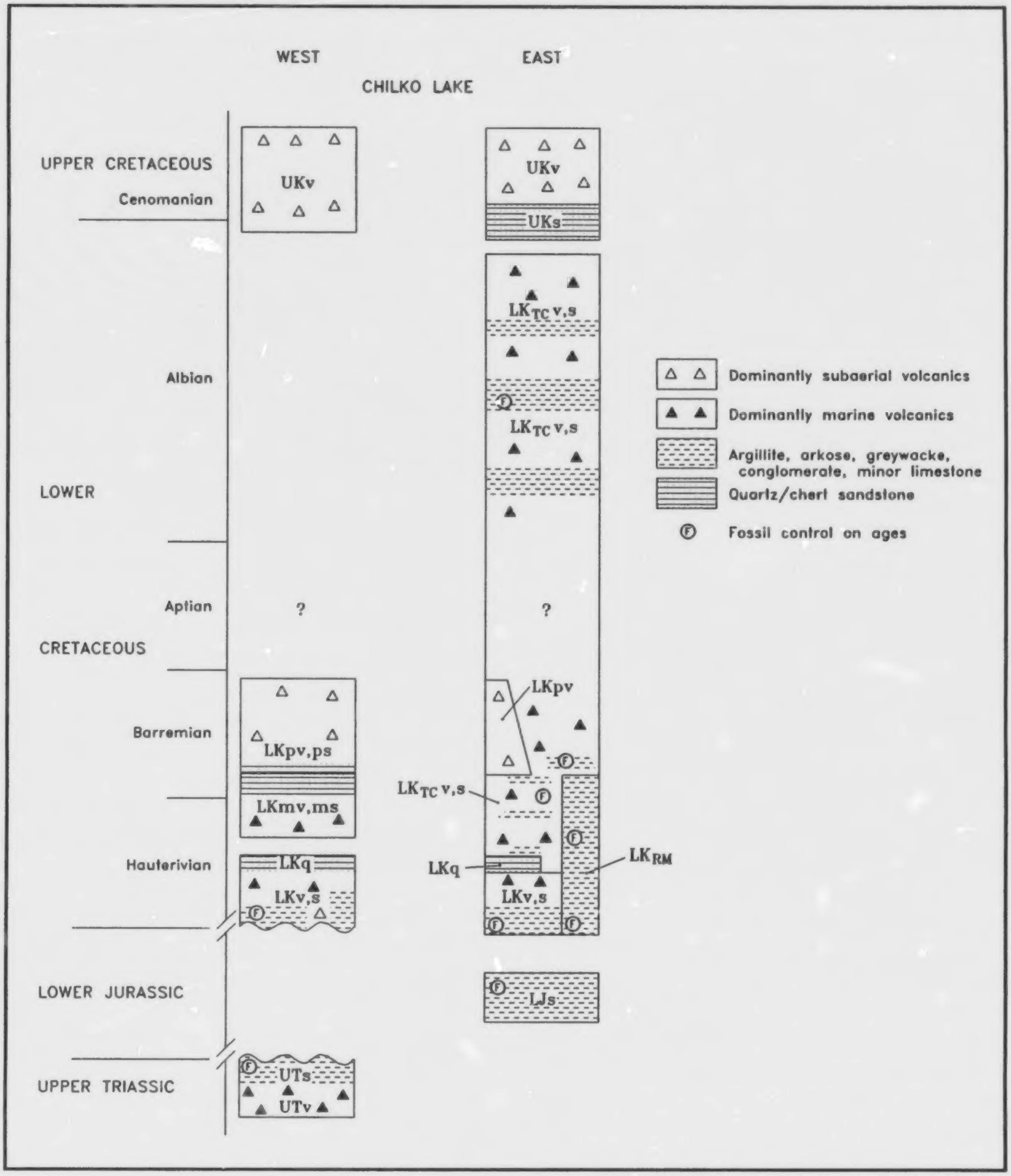

WEST
EAST
CHILKO LAKE
UPPER CRETACEOUS
Cenomanian
Albian
LOWER
Aptian
CRETACEOUS
Barremian
Hauterivian
LOWER JURASSIC
UPPER TRIASSIC
UKv
UKs
LKTC v,s
LKTC v,s
?
?
LKpv
LKpv,ps
LKmv,ms
LKTC v,s
LKq
LKq
LKRM
LKv,s
LKv,s
LJs
UTs
UTv
Dominantly subaerial volcanics
Dominantly marine volcanics
Argillite, arkose, greywacke, conglomerate, minor limestone
Quartz/chert sandstone
Fossil control on ages

Figure 7. Time-stratigraphic relationships of rock units in the Chilko Lake Planning Area.

TABLE 1
STRATIGRAPHIC CORRELATIONS IN SOUTHWESTERN BRITISH COLUMBIA

	Age	Rock Types	This Paper 92N 920	Tipper 1978 920	Tipper 1969 92N	Glover and Schiarizza 1987, 1988 920	Woodsworth 1979 Mount Raleigh	Roddick 1965 Coast Mountains	Arthur 1986 Harrison Lake
LATE CRETACEOUS	Cenomanian	volcanics	UK_v	Kingsvale Group	19	Powell Creek Formation			
		sediments	UK_s		18	Silverquick Formation			
EARLY CRETACEOUS	Albian Aptian	volcanics and sediments	LK_{TC}	Taylor Creek Group	16	Taylor Creek Group	Styx Formation	Middle Gambier Group	Brokenback Hill Formation
	Barremian	volcanics	LK_{pv}		15		Mount Eurydice Formation	Lower Gambier Group	
		sediments	$LK_{ps}LK_{TT}$						
		sediments	LK_{ms}						
		volcanics	LK_{mv}						
	Hauterivian	sediments	LK_{RM}	Relay Mountain Group	9	Relay Mountain Group			
		sediments	LK_q						
		volcanics/ sediments	$LK_{v,s}$	lkv	12				
MIDDLE/LATE JURASSIC		sediments		Relay Mountain Group		Relay Mountain Group			
EARLY JURASSIC		sediments	LJ_s	Upper Tyaughton Group	8	1c			
LATE TRIASSIC		volcanics sediments	$UT_{v,s}$		1				

subaerial ($LK_{pv,ps}$) island arc sequence. A westerly derived quartz-rich clastic sequence (LK_q) occurs within the volcanic-sedimentary assemblage.

Lower Jurassic (LJ_s) rocks occur along the Tchaikazan fault zone east of Chilko Lake, however, their extent and relationship with other sedimentary units is unknown. Lower Cretaceous volcanic island arc lithologies ($LK_{v,s}$; LK_{pv}) outcrop east of Chilko Lake and portions are conformably overlain by intercalated volcanic and clastic sedimentary rocks of Hauterivian to Albian age that are not seen west of the lake. These clastic sedimentary units (LK_{RM}; LK_{TCs}) are correlatives of Tyaughton trough strata (Table 1) whereas the volcanic members (LK_{TCv}) are thought to be related to the western volcanic island arc assemblage.

Upper Cretaceous volcanic and sedimentary rocks ($UK_{v,s}$) are separated from the older units by the Tchaikazan fault; these rocks are correlative with nonmarine assemblages that marked the end of basinal clastic sedimentation in the Tyaughton trough.

Lower Cretaceous stratigraphy established here for the Chilko – Taseko lakes area is temporally equivalent to that previously established by Jeletzky and Tipper (1968), however the lithostratigraphic sections are considerably different. Lower Cretaceous volcanic and sedimentary rocks mapped in the Mount Waddington area (Tipper, 1969; Rusmore and Woodsworth, 1988) are correlative with units mapped in this study.

Parts of the Cretaceous stratigraphy in the Chilko – Taseko lakes area are lithologically similar to rocks exposed in the Mount Raleigh pendant, 45 kilometres to the southwest (Woodsworth,1979) and with Lower Cretaceous volcanic and sedimentary rocks in the Harrison Lake area (Arthur, 1986; Ray *et al.*, 1984). Woodsworth, Ray and Coombes (1985) and Arthur have all suggested correlations with the Gambier Group described by Roddick (1965) in the southern Coast Mountains. Sutherland-Brown (1971) has also indicated that volcanic and marine sedimentary rocks in the Britannia area contain Albian ammonites and are correlative with the Gambier Group. Even though correlations based on lithologic similarities across these distances may be tenuous, they do provide useful comparative stratigraphic frameworks. Figure 8 locates other Lower Cretaceous volcanic assemblages in southwestern British Columbia.

The volcanic environments recorded by Units LK_v, LK_{mv}, LK_{pv} and LK_{TCv} in this study are probably correlative with similar rocks in the Mount Raleigh pendant and other early Cretaceous pendants in the southern Coast Mountains. All these pendants contain volcanic rocks and gently plunging structures developed prior to plutonism (Woodsworth, 1979) that are distinctly similar to those of the Chilko

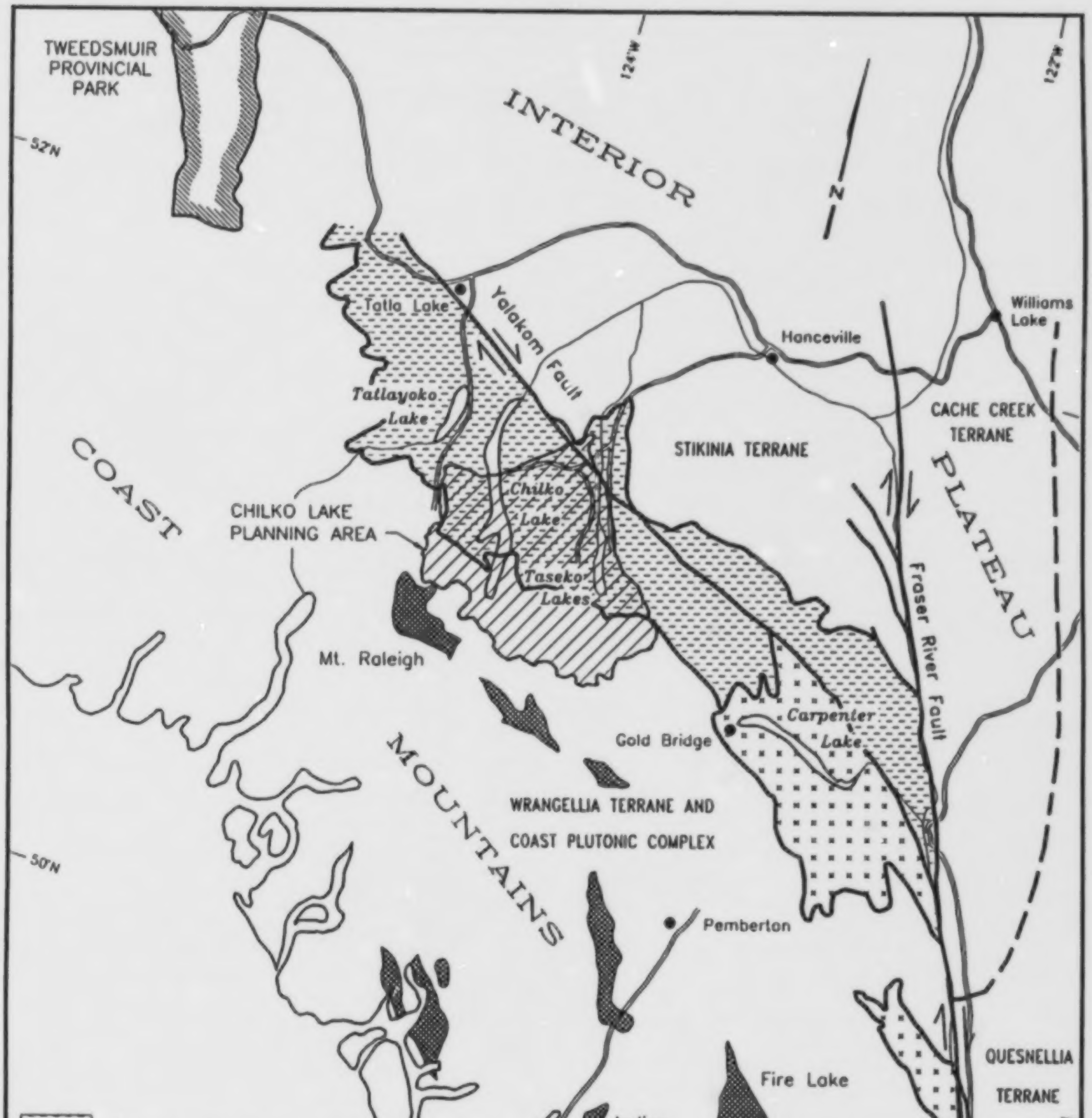

TWEEDSMUIR PROVINCIAL PARK
124°W
122°W
52°N
50°N
INTERIOR
N
Tatla Lake
Yalakom Fault
Williams Lake
Hanceville
Tatlayoko Lake
CACHE CREEK TERRANE
STIKINIA TERRANE
COAST
PLATEAU
CHILKO LAKE PLANNING AREA
Chilko Lake
Taseko Lakes
Fraser River Fault
Mt. Raleigh
Carpenter Lake
Gold Bridge
MOUNTAINS
WRANGELLIA TERRANE AND COAST PLUTONIC COMPLEX
Pemberton
QUESNELLIA TERRANE
Fire Lake
Indian River
Britannia Mine
Harrison Lake
Vancouver
CANADA
U.S.A.
0
50
KILOMETRES
Tyaughton–Methow trough
Bridge River–Hozameen terranes
Cretaceous volcanic assemblages

Figure 8. Correlative Lower Cretaceous volcanic assemblages in southwestern British Columbia.

– Taseko lakes area. Mineralization in these pendants includes the Britannia mine and several gold occurrences near Harrison Lake. The Seneca massive sulphide deposit, also near Harrison Lake, formed in a similar Jurassic volcanic island arc environment.

STRATIFIED ROCKS

UNIT UT$_{s,v}$

The oldest rocks exposed in the map area consist of an interbedded sequence of intermediate to basic volcanic flows and pyroclastic rocks, fine clastic sediments and limestones, that outcrop in fault-bounded wedges in the valley of Deschamps Creek and at the headwaters of Tredcroft Creek. Intrusive stocks cut these rocks in both locations and have developed extensive hornfels zones in the Deschamps Creek area.

Volcanic lithologies predominate and consist of intermediate to basic flows, interflow breccias and associated lithic fragmental tuffs. Pillow basalt flows are well exposed on the ridge dividing the southern headwaters of Tredcroft Creek (Plate 3). The pillows are up to 1 metre across and are composed of aphanitic dark grey material with numerous siliceous, calcareous or chloritic amygdules. Radial cooling fractures filled with quartz are common. Interpillow material consists of chloritized pillow fragments set in a siliceous or pale grey clay-rich matrix. Massive unpillowed flows are present, as are beds of interflow breccia. Feldspar-augite crystal to lithic fragmental tuffs and breccias, reworked volcanic epiclastic rocks and some argillaceous sediments displaying flame structures, scours and volcanic bombs, are interbedded with the flow units. Elsewhere purple or green, coarse lithic fragmentals predominate. These rocks have been thoroughly fractured and infilled by an anastamosing network of quartz-carbonate veins. North of Tredcroft Glacier fosilliferous grey crystalline limestone is interbedded with limy argillaceous sediments and fine lithic to crystal tuffs. Layered algal structures are present in the limy sediments.

The calcareous sediments have previously been dated as Late Triassic (Karnian to Norian: Jeletzky, 1968; Tipper, 1969) on the basis of fossils located north of Tredcroft Glacier. Fragments of megalodont bivalves and corals collected in this study indicate a similar age (H.W. Tipper, personal communication, 1987: GSC locality C-117513). The contact with overlying Lower Cretaceous sediments (Unit LK$_s$) at this locality appears to be unconformable with only a small angular discordance, as reported by Tipper (1969). In all other areas these Triassic rocks are in fault contact with adjacent units. The limy and hornfelsed rocks in

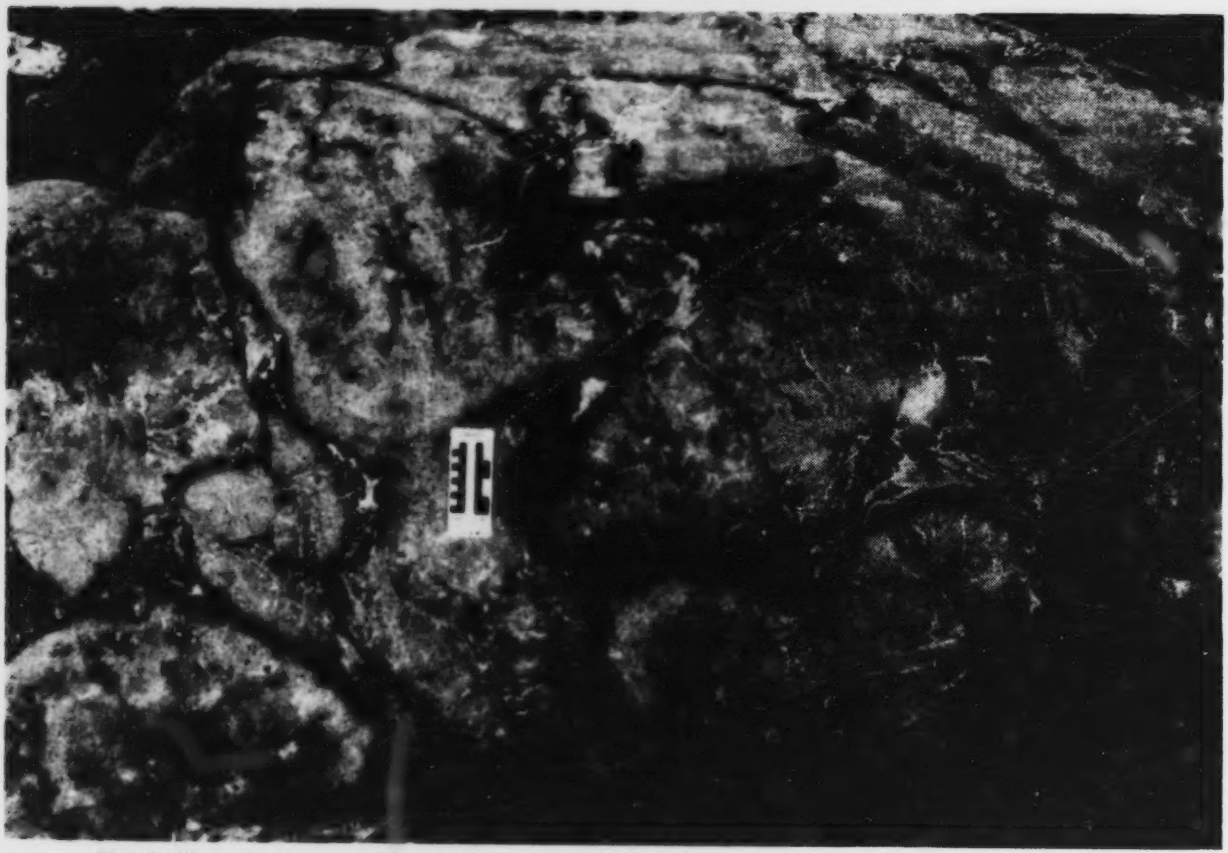


Plate 3. Pillow basalts of Unit UT$_v$ in the headwaters of Tredcroft Creek showing quartz-filled radial cooling fractures and interpillow breccia. Scale is 10 centimetres long.

Deschamps valley are assigned to this Triassic section on the basis of lithologic similarities. The occurrence of intrusions and faults in both locations indicates that these rocks have been structurally uplifted and exposed through erosion.

Similar Upper Triassic rocks outcrop extensively along the contact of the Coast intrusions to the northwest (Tipper, 1969). Rusmore and Woodsworth (1988) have described a Karnian to Norian volcanic unit with lesser sediments, informally called the Mount Moore volcanics, that is probably correlative with the Upper Triassic rocks mapped in this study. These authors argue for a correlation of this unit with volcanic rocks of the Takla Group in Stikinia Terrane.

UNIT LJ$_{s}$

A section of grey to brown-weathering argillaceous to arkosic sediments with interbedded calcareous members was mapped immediately north of the Tchaikazan fault zone on the north side of Yohetta valley. Similar lithologies were seen to the southwest of Fishem Lake. These immature sediments were previously thought to be part of the overlying Upper Cretaceous sedimentary and volcanic succession mapped higher on the ridge north of Yohetta valley (McLaren, 1986b), however, recent identification of trigoniid bivalves collected north of Yohetta Lake, 100 metres north of the fault zone, now indicates an Early Jurassic age (T. Poulton, personal communication, 1987). For this reason the sediments immediately north of the Tchaikazan fault zone in the Yohetta valley have been mapped as a separate unit. The sediments southwest of Fishem Lake are similar in lithology and stratigraphic/structural location, however, without the benefit of more detailed fossil control these rocks cannot be confidently separated from the overlying Upper Cretaceous sediments.

The Jurassic sediments are characterized by rapid facies changes from fine, thinly bedded argillaceous rocks to poorly sorted greywackes with pebbly horizons. Pyritic lenses are common in the finer grained rocks. All lithologies are baked and brittle near intrusive contacts. Pebbles are mainly fine-grained mafic volcanics. Minor mafic volcanic beds that tend to be quite magnetic are intercalated with the sediments.

The fossil collection mentioned above was taken from a fine-grained limy siltstone and included bivalves and gastropods. Identified fauna include:

Frenquelliella (Kumatrigonia)(?) sp.
Entolium sp.
Astarte(?) sp.
Hiatella(?) sp.
'Ostrea' sp.
Pleuromya sp.
(GSC locality C-117258)

The trigoniid bivalve *F. (Kumatrigonia)*, identified by T. Poulton, has only been seen in Lower Jurassic rocks in North America, (Poulton, 1979) hence an Early Jurassic (most likely Sinemurian or Pliensbachian) age is suggested.

Unit LJ$_{s}$ is clearly fault bounded along its southern contact with a Lower Cretaceous purple volcanic horizon. The northern contact with overlying sediments was not observed but is assumed to be a fault subparallel to the Tchaikazan fault because overlying rocks are thought to be of Late Cretaceous age. It is impossible to confirm whether this presumed fault sliver of Jurassic rocks extends farther to the east or west without further detailed mapping.

Similar Early Jurassic lithologies were mapped by Tipper (1969, 1978) approximately 20 kilometres to the northwest in Nemaia valley. Fossil control is again poor in these rocks and the relationship to adjacent units is imperfectly known. Unit LJ$_{s}$ is also of the same age as a shale unit overlying Tyaughton Group rocks mapped to the southeast (Cairnes, 1943; Unit 1c of Glover *et al.*, 1987).

UNIT LK$_{v,s}$

Unit LK$_{v,s}$ comprises a thick succession of volcanic rocks with minor gritty sediments outcropping in a broad band across the southern part of the map area. A basal sedimentary section, Unit LK$_{s}$, is partially preserved along the contact of the Coast plutonic complex and is mapped separately as it contains distinctive lithologies. The overlying, dominantly volcanic section includes sedimentary horizons but none are thick or extensive.

UNIT LK$_{s}$

Exposures of Unit LK$_{s}$ occur in a thin discontinuous band in the upper Tchaikazan valley. This clastic sedimentary section consists of interbedded dark grey argillite, quartz-rich greywacke and chert-pebble conglomerate. Thin volcanic tuff members are also present. Bedding thickness ranges from a few millimetres to a few metres. These rocks are interbedded with overlying volcanics to the north and are truncated by quartz diorite of the Coast plutonic complex to the south. Minor hornfelsing and pyrite development is present along this contact. A sedimentary horizon mapped by Tipper (1978) south of Mount Goddard is probably correlative with this unit.

The greywackes in the Tchaikazan valley have yielded a limited collection of marine pelecypods and belemnites that includes:

Inoceramus paraketzovi Efimova 1972
subsp. *latus* Pochialainen and Terekhova 1972
Acroteuthis ex gr. *impressa* (Gabb).
(GSC locality C-117261)

These large and peculiarly ornamented *Inoceramus* forms are only known in the Hauterivian in western British Columbia, hence a general Hauterivian age has been assigned to this fauna (J.A. Jeletzky, personal communication, 1986).

UNIT LK$_{v}$

A section of volcanic pyroclastics and flows with minor interbedded sediments conformably overlies Unit LK$_{s}$. It is in contact with the Coast intrusions across the southern part of the study area. The volcanics comprise a variegated and well differentiated suite ranging from rhyolite to basalt in composition. Crystal and lithic fragmental tuffs dominate but rhyolite and columnar basalt flows are also present.

The finer tuffs generally display feldspar or mafic crystals and crystal fragments distributed through an ash-like grey, maroon or green matrix. They grade through lapilli tuffs into coarser lithic fragmental rocks containing subrounded to angular clasts of locally derived volcanics up to 25 centimetres across. Carbonates are often present in the matrix or as discrete pods. Tuffs may be subaerial or waterlain and are dominantly andesitic to basaltic in composition. Bedding is poorly developed east of Chilko Lake, but to the west these rocks are regularly interbedded with reworked epiclastic material.

Basic flows are interlayered with the tuffs, generally forming more resistant massive horizons. A prominent bluff on the west shore of Chilko Lake exposes well-developed columnar jointing in a fine-grained grey basalt. This flow overlies a layered volcanic breccia to laharic mudflow section. The lahars contain coarse volcanic boulders irregularly dispersed through a white-weathering ash-like matrix. Similar lithologies form distinctive white cliffs along strike on the east shore of Chilko Lake and irregular white lobes farther east below Mount Goddard. The shoreline section, over a kilometre in length, provides excellent exposure of a chaotic volcanic conglomerate with a layered ash flow or muddy matrix (Plate 4). Fine-grained rocks in this section are thinly laminated and display upright crossbedding features.

Rhyolitic volcanics occur throughout this unit; layered quartz-eye tuffs and breccias were noted between the Tchaikazan valley and Chilko Lake, and to the north and south of Franklyn Arm. North of Franklyn Arm the tuffs pass into massive quartz feldspar porphyry flows. Gossanous rhyolitic fragmental rocks, carrying considerable pyrite and pyrrhotite, outcrop near the contact of the Coast Complex on the east shore of Chilko Lake and along strike to the east, high on a ridge.

Sedimentary strata of Unit LK$_{v}$ consist primarily of siltstones and greywackes that are associated with volcanically derived epiclastic material. Prismatic shell fragments (*Inoceramus* sp.: GSC locality C-117511), found in a layered, hornfelsed, limy siltstone on the western slopes of Deschamps valley, are typical of fauna in Hauterivian rocks of this area, hence a general Hauterivian age is again suggested for Unit LK$_{v,s}$ (H.W. Tipper, personal communication, 1987). Similar fossiliferous sediments and volcanics were noted north of Tredcroft Glacier; fossils identified include:

Inoceramus colonicus
Acroteuthis sp.
ammonite fragments, possibly *Simbirskites* sp.
(GSC locality C-117512)

The age assigned to this fauna is early Hauterivian (H.W. Tipper, personal communication, 1987). Jeletzky (1968) previously dated these sediments as Hauterivian.

Hornfelsing of Unit LK$_{v,s}$ lithologies is widespread adjacent to the Coast plutonic complex. Zones containing 1 to 5 per cent pyrite and pyrrhotite in a variably silicified hostrock have produced broad areas of limonitic weathering.

These rocks unconformably overlie Triassic rocks as described for Unit UT$_{v,s}$; elsewhere the base of Unit LK$_{v,s}$ is truncated by the Coast plutonic complex. The upper contact is exposed in the Tchaikazan valley and on the ridge between Franklyn Arm and Chilko Lake. In the Tchaikazan valley the volcanics pass upwards conformably into sediments and volcanics of Unit LK$_{TC}$ while south of Franklyn Arm they grade conformably into Unit LK$_{q}$ sediments. Unit LK$_{v}$ is in

Plate 4. Chaotic debris flows of Unit LK$_{v,s}$, east shore of Chilko Lake west of Mount Goddard. Subrounded to angular volcanic boulders are distributed through a layered ash matrix.

Plate 5. Basal volcanic conglomerate of Unit $LK_{ms,mv}$ north of Franklyn Arm; well-rounded cobbles are of locally derived volcanic lithologies.

Plate 6. Interbedded argillite, quartzose sandstone and volcanic tuff of Unit $LK_{mv,ms}$ near the gradational contact with Unit $LK_{pv,ps}$ north of Tredcroft Creek. White crossbedded quartzose sandstone outcrops in the foreground.

fault contact with mixed volcanic and sedimentary rocks of Unit LK$_{ms,mv}$ to the north of Franklyn Arm, however, the fault masks the true nature of the stratigraphic relationship between these units as distinctly similar lithologies occur on either side of the fault.

UNIT LK$_{ms,mv}$

Interbedded sediments and volcanics of Unit LK$_{ms,mv}$ can be subdivided into a lower dominantly volcanic section (LK$_{mv}$) and an upper dominantly sedimentary section (LK$_{ms}$). These rocks are lithologically similar to rocks of Unit LK$_{v,s}$ and may represent a lateral or vertical facies change. They only occur to the west of Chilko Lake, peripheral to the purple volcanic assemblage of Unit LK$_{pv,ps}$; no similar lithologies were noted east of the lake.

The lower volcanic assemblage comprises green, purple or brown pyroclastics and flows of intermediate to felsic composition. They are characterized by feldspar-hornblende crystal tuffs that grade into thickly bedded and coarser lapilli and lithic tuffs with locally derived volcanic clasts. Thinly laminated waterlain tuffs with discontinuous black argillite beds are locally present. Laharic deposits with a fine-grained white ash-like matrix resemble those described for Unit LK$_{v}$. Flow-banded rhyolite and quartz-eye tuffs are present at two localities north of Franklyn Arm, and again resemble felsic volcanics of Unit LK$_{v}$. Erosional breaks in the volcanic sequence are recorded by thickly bedded horizons of conglomerate with well-rounded volcanic cobbles set in an epiclastic to tuffaceous matrix (Plate 5). Smaller pebbles in these rocks include quartz and cherty lithologies. This is the lowest unit in which cherty pebbles are found in volcanic conglomerates and may be indicative of developing tectonic uplift in adjacent areas, with deposition of externally derived clastic material; such quartz-rich material becomes common in the overlying sediments.

Minor argillaceous beds are present within this volcanic sequence. A pyrite-pyrrhotite-rich gossanous zone has developed on one such horizon, on ridges north and south of Tredcroft Creek.

The upper clastic sedimentary assemblage is best exposed north of Tredcroft Creek (Plate 6). These rocks consist of interbedded quartz-rich sandstone, immature greywacke, dark grey to green argillite and minor conglomerate. Thin limy horizons are also present. Argillaceous beds are commonly friable and sheared or tightly contorted. Gritty sediments display graded and crossbedding features facing northeast. Numerous volcanic tuffs and some thin flows are interbedded with the sediments.

A boulder conglomerate along the fault contact between Units LK$_{v,s}$ and LK$_{ms,mv}$ north of Franklyn Arm indicates at least a local erosional break between these units, however the similarity of lithologies across this fault zone elsewhere suggests that these rocks are conformable on a larger scale. Local breaks in the volcanic stratigraphy and the occurrence of externally derived cherty clasts may record the onset of intermittent uplift. No diagnostic fossils have been found in the upper sedimentary assemblage, however a thin limy horizon, contained within argillites, is crowded with numerous bulbous organisms resembling sponges or possibly hydrozoans (H.W. Tipper, personal communication, 1987). This fauna most likely records a near-shore marine basinal environment. Higher in the section, crossbedded quartzose sandstones record a nonmarine fluvial environment, again with externally derived clastic sedimentation. The contact between the upper sedimentary assemblage and the overlying purple rocks of Unit LK$_{pv,ps}$ is gradational and reflects a change from neritic to subaerial conditions. The lack of fossils precludes assigning a definite age to this unit, however, the stratigraphic relationships with Unit LK$_{v,s}$ suggest it is Hauterivian or younger.

Mixed sediments and volcanics outcropping in the headwaters of Alexis Creek, and south and west of the head of Why Not Creek, were included in this unit on the basis of lithological similarities, a conformable contact with the overlying purple rocks and on their position around the broad synclinal structure cored by the purple volcanics of Unit LK$_{pv,ps}$. Here Unit LK$_{ms,ms}$ is in fault contact with Unit LK$_{q}$ along the Tchaikazan fault zone.

Intense faulting and shearing are evident in the sedimentary sections of Unit LK$_{ms}$ in both areas of outcrop. North of Tredcroft Creek the sediments are overturned and shattered at one location and tightly contorted into disharmonic folds at another. These rocks are particularly susceptible to deformation and appear to have responded in a more ductile fashion than the surrounding volcanics.

UNIT LK$_{pv,ps}$

A thick succesion of purple volcanics and sediments forms the core of a broad syncline west of Chilko Lake. The base of the unit is dominantly sedimentary (LK$_{ps}$), but passes quickly into a volcanic sequence (LK$_{pv}$) dominated by pyroclastic rocks. These rocks are lithologically similar to the underlying sediments and volcanics of Unit LK$_{ms,mv}$; however, due to their distinctive colour and subaerial depositional environment they are mapped separately. East of Chilko Lake the volcanic portion of this unit crops out in a fault-bounded belt that extends to the Tchaikazan valley.

The sediments of Unit LK$_{ps}$ comprise a well-bedded sequence of greywackes and conglomerates that often grade into epiclastic volcanic material (Plate 7). The base is clearly transitional with the white quartzose sediments and argillites of Unit LK$_{ms}$, but tuffaceous and argillaceous clasts, set in a matrix containing detrital hematite, become more common as these rocks pass upwards into the overlying volcanics. Single beds may change colour along strike, probably reflecting variations in hematite content. The only fossils seen in these sediments are nondiagnostic gastropods; no clearly marine fossils were found. This sedimentary package was not observed east of Chilko Lake, however sedimentary clasts were noted in some of the lithic fragmental volcanics here.

Pyroclastic rocks dominate the upper volcanic assemblage; feldspar or feldspar-hornblende crystal tuffs grade into heterolithic tuffs and breccias. Poorly sorted lithic fragments, generally up to 25 centimetres in size, include dark grey to purple hornblende-feldspar crystal tuff, dark grey feldspar porphyry flows, green chloritic hornblende porphyry and some green, strongly chloritized tuff. Argillaceous to arkosic sedimentary fragments and dioritic intrusive fragments are also present. The matrix material is a feldspar-rich crystal tuff containing sufficient finely disseminated hematite to impart an overall purple colour to the unit; magnetite and carbonates are common accessories. Layered epiclastic units are occasionally present, but bedding is not well developed in the coarser pyroclastics. More massive flows or irregular bodies of intrusive feldspar porphyry form resistant ridges within the tuffaceous rocks.

Unit LK_{pv} volcanics often form prominent rugged peaks through the centre of the map area. These resistant, blocky lithologies tend to fracture brittly and develop carbonate, silica or epidote alteration zones along fracture planes. Copper-bearing quartz-carbonate veins with epidote selvages up to 2 metres wide occur north and south of Girdwood Lake. Fracture zones with quartz-carbonate alteration and veining carrying copper mineralization are widespread within these volcanics to the west of the lower Tchaikazan valley.

East of Chilko Lake two major fault zones bound this unit. The northern contact, the Tchaikazan fault (Tipper, 1978), is poorly exposed through the Yohetta valley. The southern fault is clearly exposed at two mapped locations: one is an outcrop of strongly sheared fault breccia consisting of large rotated blocks of altered volcanic tuffs set in a white carbonate matrix; the second is a gossanous shear zone 25 metres wide containing silicified and bleached volcanic fragments with vuggy quartz-carbonate veins carrying pyrite, pyrrhotite and minor chalcopyrite.

The age of this unit is not well constrained as no diagnostic fossils have been found. Stratigraphic relationships west of Chilko Lake and the overall volcanogenic environment suggest an age similar to that of Unit $LK_{ms,mv}$, that is Hauterivian or younger. It is uncertain whether the volcanism represented by these units continued into the Barremian.

UNIT LK_{RM}

The fine clastic sediments of Unit LK_{RM} are distinctive in their rich, marine fossil fauna, evident in at least six locations within the narrow wedges of exposed strata south of Yohetta Lake and in the lower Tchaikazan valley. Sedimentary facies are closely interbedded and include thinly laminated grey siltstone to black argillite as well as concretionary brown siltstones to arkosic sandstones in beds often a few metres thick. Limy sections or impure limestones are common. Tuffaceous volcanic horizons are present, particularly adjacent to the contact with the overlying volcanics of Unit LK_{TC}. Hornblende-feldspar crystal and lapilli tuffs comprise the volcanics, and epiclastic volcanic material, including volcanic conglomerate, is mixed with the sediments.

The contact with overlying volcanic rocks is seen to be a fault in most locations but elsewhere Unit LK_{RM} sediments appear to pass upwards into a coarse volcanic conglomerate with interbedded concretionary greywacke which in turn

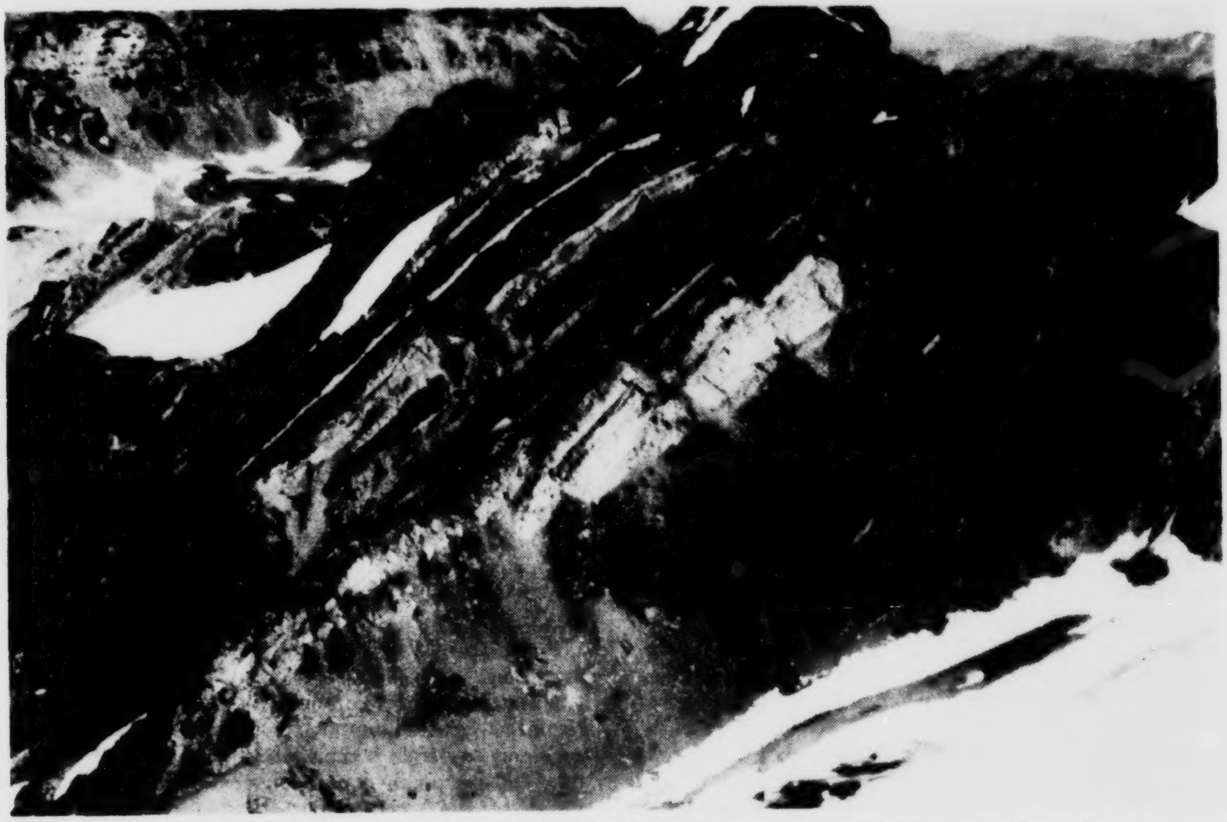


Plate 7. Interbedded variegated sediments and volcanic tuffs of Unit $LK_{pv,ps}$ near the gradational contact with Unit $LK_{mv,ms}$ southwest of Girdwood Lake. Thickly layered overlying volcanics of Unit LK_{pv} are visible in the background (upper left).

passes into fragmental volcanics of Unit LK_{TC}. If the contact is conformable, Unit LK_{RM} would be correlative in part with the volcanics in the upper part of Unit $LK_{v,s}$. Unit LK_{RM} sediments are richly fossiliferous. Fossil collections, taken from three sites containing a diversity of shelly fauna and some fossilized wood fragments south of Yohetta Lake, were identified by J.A. Jeletzky; they include the following:

Site 1: near the westernmost fault pinch-out of this unit

Inoceramus n. sp. indet.

Inoceramus cf. *paraketzovi* Efimova 1972

(GSC locality C-117256)

The *Inoceramus* n. sp. indet. is a somewhat diagnostic form that appears to be restricted to the lower Hauterivian. *Inoceramus paraketzovi* is more wide ranging but is restricted to the Hauterivian in general.

Site 2: 500 metres southwest of Site 1

Protetragonites sp. indet.

Quoicecchia aliciae Crickmay 1930

Acroteuthis ex gr. *impressa* (Gabb)

Pleuromya ex gr. *vancouverensis* Whiteaves

Inoceramus sp. indet.

(GSC locality C-117255)

The bivalve *Quoiecchia aliciae* Crickmay 1930 is restricted to the Hauterivian-Barremian rocks of western British Columbia.

Site 3: 1500 metres northwest of the eastern pinchout of this unit.

Homolsomites oregonensis Anderson 1938

Inoceramus n. sp. indet.

Inoceramus paraketzovi Efimova 1972

Acroteuthis (s. lato) sp. indet.

(GSC locality C-117257)

The *Homolsomites oregonensis* zone represents a basal Hauterivian age. The above comments on age and distribution of fossils are all paraphrased from Jeletzky (personal communication, 1986).

Jeletzky and Tipper (1968) have previously studied these rocks in detail and measured a section at Site 3. Rocks in this section ranged in age from latest Valanginian near the northern contact through the early lower Hauterivian (*Homolsomites oregonensis* zone) to the late lower Hauterivian (*Homolsomites packardi* zone) near the southern contact. These beds are slightly overturned to the north in this section. The volcanic rocks to the south are reported to be of middle Hauterivian age. These ages infer a conformable contact between Units LK_{RM} and LK_{TC} at this point, as suggested by field relationships.

Fossils collected from the thin wedge of this unit outcropping above the lower Tchaikazan valley include:

Quoiecchia aliciae Crickmay 1930

Inoceramus n. sp. indet.

Acroteuthis sp. indet.

(GSC locality C-117259)

This faunal association strongly suggests an early Hauterivian age, similar to that of Sites 1-3 (J.A. Jeletzky, personal communication, 1986).

UNIT LK_{TC}

Unit LK_{TC} is composed of intercalated volcanic, volcaniclastic (LK_{TCv}) and clastic sedimentary rocks (LK_{TCs}) outcropping in a broad synclinal structure east of Chilko Lake. There are regular gradations from tuffaceous volcanics to epiclastics to greywackes, and it is difficult to segregate sedimentary and volcanic members. Rapid facies changes inhibit the definition of extensive stratigraphic horizons.

The volcanic members of Unit LK_{TCv} comprise multicoloured dacitic to basaltic pyroclastics, vesicular flows and flow breccias. Crystal, lapilli and lithic tuffs predominate. Lithic fragments are generally intraformational and are set in a fine-grained, feldspar crystal tuff matrix. These rocks are often layered, but are generally poorly sorted. Flow rocks are fine grained, green to grey, and commonly contain calcareous or chloritic amygdules and epidote knots. Chalcedonic amygdules and red or green jasperoidal lenses are also present in some flows. A distinctive grey vesicular flow, extending from the Tchaikazan valley to southwest of Spectrum Peak, locally contains 1 to 3 per cent pyrite or pyrrhotite in silicified and fractured sections. Interflow breccias are common at this horizon. A prominent blocky assemblage of flows, flow breccias and epiclastic rocks overlies the vesicular flow unit. Felsic members of the unit tend to be fine-grained pale grey tuffs that are moderately siliceous and contain thin bands with fine quartz eyes; however, they comprise a small proportion of the total volcanic section.

Sedimentary lithologies in Unit LK_{TCs} include dark grey argillites, siltstones, brown greywackes, and chert-pebble conglomerate as well as minor quartzose sandstone and impure limestone. The base of the unit in the Tchaikazan valley is marked by conglomerate and arkosic sediments from 2 to 20 metres thick that conformably overlie volcaniclastics of Unit $LK_{v,s}$. The conglomerates are white to pale grey and composed of cherty or siliceous pebbles set in a calcareous sandy matrix. Argillaceous and volcanic pebbles become more common as this layer grades into the overlying or underlying volcanics. Carbonized tree trunk fragments have been recovered from the conglomerate. Elsewhere in Unit LK_{TCs}, dark grey argillites and grey to brown siltstone and greywacke are typically well bedded and locally display grading or crossbedding.

An extensive marine fossil collection was taken from a greywacke-conglomerate section north of Mount Goddard. Fauna identified from this location (J.A. Jeletzky, personal communication, 1986) include:

Brewericeras hulenense (Anderson 1938)

Panope (s. lato.) sp. indet.

Lima (s. lato.) sp. indet.

Nerinaeid? gastropods resembling *Vernedia* Mazeran 1912

indeterminate ammonoid, pelecypods, gastropods

indeterminate rhynchonellid brachiopod

(GSC locality C-117260)

The *Brewericeras hulenense* zone was previously described from sediments of Unit LK_{TCs} on a ridge above the lower Tchaikazan valley and elsewhere in the Tyaughton trough (Jeletzky and Tipper, 1968); this faunal zone represents a late lower Albian age.

A limited collection of nerinaeid gastropods, belonging to the family Itieriidae Cossman 1896, was taken from argillites below a felsic volcanic contact in the Tchaikazan valley (GSC locality C-117254). This family appears to range from Albian to Maestrichtian in age, however, as no marine rocks younger than Albian are known to occur anywhere in the

Tyaughton trough, a general Albian age is tentatively suggested for these gastropods (J.A. Jeletzky, personal communication, 1986). Similar gastropods occur in reliably dated Albian rocks elsewhere in southern British Columbia.

South of the Tchaikazan valley, on Twin Creek, a collection of nondiagnostic gastropods, bivalves and belemnites was collected from argillites interbedded with volcanic rocks (GSC locality C-117508). Even though no definite age can be assigned to this collection, the occurrence of belemnites renders an Albian age unlikely as they are not known in the Albian of Canada. A pre-Aptian (possibly Barremian or Hauterivian) age is probable in this map area (H.W. Tipper, personal communication, 1987). Note that Jeletzky and Tipper (1968) report a middle Hauterivian age for the Unit LK_{TCv} volcanics in contact with the early Hauterivian sediments of Unit LK_{RM}.

The above age determinations indicate that sedimentation and volcanism represented by this unit may be coeval or at least conformable with the underlying Hauterivian volcanics and sediments. Deposition of Unit LK_{TC} lithologies then continued until the late Lower Cretaceous.

Clastic sediments of Unit LK_q appear to interfinger with Unit LK_{TC} lithologies southwest of Spectrum Peak. The top of Unit LK_{TC} is not exposed and the relationship with younger Upper Cretaceous rocks is not known.

UNIT LK_q

Well-bedded quartz and chert-rich clastic sedimentary lithologies occur in a series of stacked thrust sheets near Tredcroft Glacier and as a distinct layered section between Franklyn Arm and Chilko Lake. Argillaceous rocks are interbedded with the coarser clastics and tuffaceous horizons are also present. Quartz and chert-rich clastic lithologies west of Spectrum Peak, to the east of Chilko Lake, are mapped with this unit on the basis of distinctly similar lithologies and provenance.

Conglomeratic horizons, most common lower in the section, are usually discontinuous channel or floodplain deposits. Chert and quartz generally account for 80 to 85 per cent of the clasts; argillite and volcanics make up the remainder. Clasts are set in a gritty quartzose matrix. Sandstones are grey to white, clast-supported quartz-rich rocks with sparse, weakly calcareous cement; argillite grains are locally present. Dark grey argillite and some siltstone are interbedded with the coarser rocks. Occasionally these become greenish and appear glauconitic. Brown calcareous concretions weather out of the finer sediments as large round balls. Tuffaceous or volcanic epiclastic material, represented by feldspar crystals or broken crystal pieces, was noted at a number of horizons.

A variety of bedding features, including crossbedding, graded bedding, channel scours and flame structures, indicate a northeasterly facing sequence with a westerly source (Plate 8). All the above features strongly suggest deposition in an active deltaic environment. Pockets of carbonized organic debris are characteristic of this unit. Fossilized logs, up to a metre long, were found in several localities, including high above the west shore of Chilko Lake (Fry, 1959) and in the headwaters of Tredcroft Creek. Samples of argillaceous material collected from this unit for microfossil analysis provided no reliably identifiable palynomorphs (A.R. Sweet, personal communication, 1987).

The base of this unit was observed only on the ridge between Franklyn Arm and Chilko Lake, where these sediments are interbedded with volcanics of Unit LK_v. On the ridge crest the volcanic rocks grade into the sediments with no major breaks, while in a creek valley to the east, the sediments and volcanics clearly interfinger. The creek valley lies along a fault zone containing numerous slivers of mixed volcanic and sedimentary rocks, however, the faults do not separate lithologies. East of Chilko Lake these well-bedded quartz-rich sediments are interbedded with volcanics and sediments of Unit LK_{TC} and are cut by an intrusive stock of granodiorite (Plate 9). This intrusion has produced minimal contact metamorphic effects on the surrounding quartz-rich sediments. Elsewhere all contacts appear faulted or are covered. Numerous thrust faults cut the unit at the head of Tredcroft and Torch creeks where spectacular recumbent asymmetric folds are exposed.

UNIT UK_s

Unit UK_s comprises a sequence of interbedded argillite, greywacke, quartzose sandstone and pebble conglomerate that is exposed from the lower Tchaikazan valley to the Yohetta valley, and to the northwest near Alexis Creek. Impure limy sections are common and large limy concretionary boulders weather out of the sandstone and conglomerate. Conglomeratic members range from clast to matrix supported; clasts are dominated by quartzose or cherty lithologies, but argillite, greywacke and minor volcanic pebbles are also present. The upper members of the unit are well bedded, displaying grading, crossbedding and channel scour marks that indicate an upright sequence with a westerly source. Thin volcanic layers are present within the sediments, forming resistant ridges of grey-green feldspar hornblende porphyry flows with minor tuffs.

This unit has an abrupt but apparently conformable contact with the overlying volcanic rocks of Unit UK_v (Plate 10), however, in most locations it is bounded on the south by the Tchaikazan fault zone.

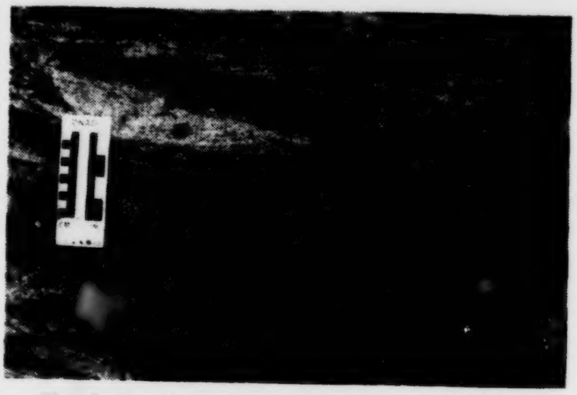


Plate 8. Crossbedded quartzose sandstone of Unit LK_q west of Chilko Lake.

UNIT UK$_v$

Intermediate to basic pyroclastics, flows and conglomerates of Unit UK$_v$ outcrop across the northern quarter of the area mapped. Purple and green andesitic breccias and tuffs predominate. Angular lithic fragments are generally up to 15 centimetres across and are composed of locally derived crystal tuff. The fragmental rocks occasionally grade into thick beds of volcanic conglomerate with well-rounded volcanic boulders resting in a tuffaceous or epiclastic matrix. The boulders are up to a metre across and are derived from the surrounding volcanics or from subvolcanic intrusions of similar composition. Interbedded tuffaceous members, including some very finely laminated waterlain tuffs, occur in discontinuous layers. Bedding in these rocks outlines a broad syncline immediately east of Chilko Lake between Long and Nemaia valleys. Finer grained, more massive flows, with fine mafic needles, are locally intercalated in the tuffs. Magnetite and carbonates are common accessory minerals in all the volcanics.

MESOZOIC PALEOENVIRONMENT

Rocks exposed in the study area primarily provide information on the Early Cretaceous depositional environments, however, important points can be made regarding the older rocks as well.

Upper Triassic rocks mapped in this study are probably part of the Triassic island arc assemblage (Mount Moore volcanics) suggested to be part of Stikinia by Rusmore and Woodsworth (1988). West of Chilko Lake these rocks are unconformably overlain by Lower Cretaceous strata, further supporting the contention that the region was uplifted during Jurassic time. The general lack of Jurassic aged Relay Mountain Group lithologies indicates that Tyaughton trough sedimentation was not extensive west of Taseko Lakes during the Jurassic.

The Lower Cretaceous stratigraphy records a volcanic island arc setting, with both marine and subaerial components, that interfingers with Hauterivian to Albian sediments deposited on the southwest flank of the Tyaughton trough. Fossils indicate Hauterivian, pre-Aptian and Albian periods of sedimentation. No reliably dated Barremian or Aptian units have been documented, however, this has been noted as a period of limited sedimentation of poorly fossiliferous rocks in the Tyaughton trough (Jeletzky and Tipper, 1968), hence sedimentary rocks of this age may easily escape detection within the complexly faulted, mixed facies of Unit LK$_{TC}$. Volcanism probably occurred intermittently throughout this time in the uplifted island arc. Incursions of fluvial, crossbedded chert and quartz-rich clastic sediments (LK$_q$) indicate uplift of adjacent lands to the west, probably related to the emergence of late Hauterivian to Barremian(?) subaerial volcanic islands (Unit LK$_{pv,ps}$).

Plate 9. Well-bedded sediments of Unit LK$_q$ cut by a granodiorite stock(gd) southwest of Spectrum Peak.

Plate 10. Unit UK_s recessive argillite and greywacke, interbedded with ridges of quartzose sandstone and volcanic flows, form the lower slopes and are overlain conformably by massive volcanics of Unit UK_v north of Yohetta Lake.

The westerly derived quartz sandstones within Unit UK_s indicate renewed uplift in the west during the latest Early Cretaceous. This unit, together with the thick sequence of overlying subaerial volcanics (UK_v), marks the end of basinal sedimentation and a progression into a broad terrestrial volcanic environment of Late Cretaceous age.

The relative ages of these Lower Cretaceous volcanic and sedimentary depositional environments are supported by stratigraphic relationships established by Jeletzky and Tipper (1968) for the sedimentary domains in the centre of the Tyaughton trough. The Relay Mountain Group in the Taseko Lakes map area includes a late Hauterivian variegated clastic unit with minor interbedded volcanics that decreases steadily in thickness to the east; a piedmont depositional environment with a source to the southwest, that is towards the Chilko Lake area, is suggested. This source area would be represented by the uplifted island arc recorded in Units LK_{mv}, LK_{pv} and LK_{TC}. An *Inoceramus colonicus* fauna found beneath both the variegated clastics and the uplifted source rocks confirms their coeval relationship.

During the Barremian, fine-grained variegated clastic rocks with a poor fossil record indicate limited deposition in a broad lagoonal or deltaic environment; marine deposition was restricted to more eastern portions of the trough. The Aptian was generally a time of nondeposition, however, widespread marine transgression during the late lower Albian is recorded by sediments carrying the *Brewericeras hulenense* fauna. Volcanic conglomerates, epiclastic sedimentation and local marine sedimentation are recorded within Unit LK_{TC} during the periods of limited sedimentation elsewhere in the trough. The diagnostic *Brewericeras hulenense* fauna is present in sediments of Unit LK_{TC} interbedded with volcanics near Mount Goddard. This is the westernmost reported occurrence of this fauna in the Tyaughton trough.

INTRUSIVE ROCKS

UNIT A – DIORITE STOCKS, DIKES

Irregularly shaped diorite to quartz diorite intrusions cut the volcanic-sedimentary stratigraphy with variable contact metamorphic effects. A number of these stocks follow a northwesterly trend from the Tchaikazan valley to Chilko Lake and may have intruded along fault zones. These rocks display medium to fine-grained feldspar and hornblende phenocrysts crowded in a fine-grained crystalline matrix. Partially chloritized biotite is a common constituent: quartz and magnetite are generally minor accessories. Chlorite-epidote-carbonate alteration is also common. Numerous dikes and irregularly shaped dioritic bodies in the Tarn Creek area are thought to represent the roof of a larger stock below.

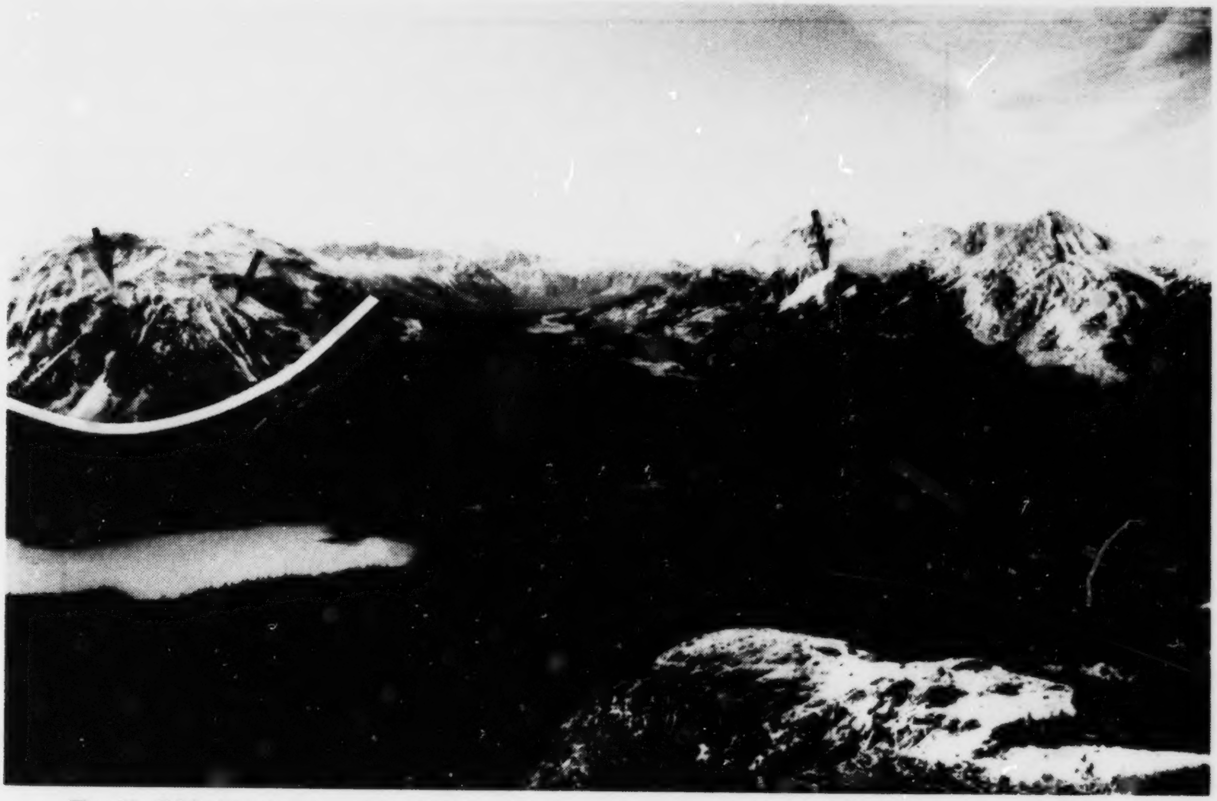


Plate 11. Felsite intrusions (arrows) cutting Upper Cretaceous sediments and volcanics (UK_S, UK_V) in Yohetta valley (looking west).

Copper mineralization, associated with fracturing, hornfelsing and propylitic alteration of surrounding rocks, is present at this location and adjacent to the Mount Goddard intrusion. These stocks are less common west of Chilko Lake, however, a variety of dioritic and fine-grained felsic intrusions outcrops near Alexis Creek. This area lies along the same northwest-trending lineament intruded east of the lake. The precise age of these intrusions is unknown; however, as they cut volcanics of Unit UK_V they are presumed to be Late Cretaceous or younger.

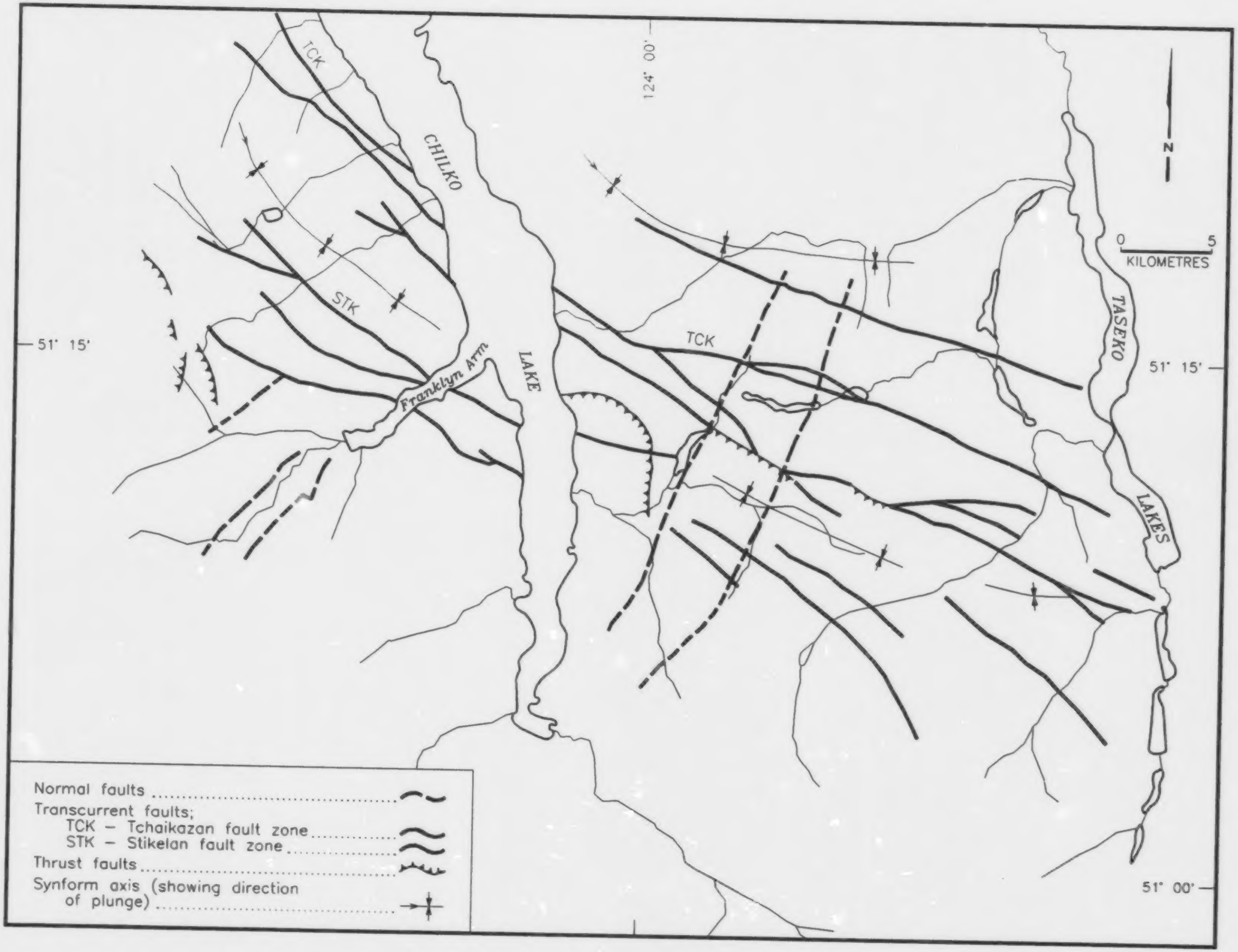
UNIT B — FELSITES

A group of distinctive white-weathering intrusive stocks occurs within a fault-bounded wedge of volcanics and sediments between Taseko Lakes and the Yohetta valley. These rocks include feldspar and biotite feldspar porphyries with considerable variation in number, size, and crowding of phenocrysts. Intense quartz-carbonate alteration is present adjacent to the stock, north of Yohetta valley (Plate 11). Tipper (1978) assigned an Eocene age to these intrusions. No mineralization was noted associated with them, however, the government regional geochemical survey of the area (British Columbia Ministry of Energy, Mines and Petroleum Resources, 1979) identified a number of anomalous geochemical values in silt from creeks in this area.

UNIT C — COAST PLUTONIC COMPLEX

Massive equigranular granodiorite and quartz diorite intrusions of the Coast plutonic complex outcrop across the southern and southwestern margins of the map area. No attempt was made to map these in detail. Satellitic stocks cutting the volcanic-sedimentary succession are common (Plate 10). Extensive hornfelsing, accompanied by disseminated or veinlet pyrite-pyrrhotite mineralization, is common throughout rocks of Units LK_V and LK_{TC} adjacent to the intrusions. Quartz veinlets carrying molybdenite south of Tredcroft Glacier and the skarn development in Deschamps valley may also be related to these intrusions. The irregular shape of the intrusive contacts, and the extensive hornfelsing between Franklyn Arm and Chilko Lake, suggest that intrusive rocks underlie much of this area at a relatively shallow depth. This may also be true east of Chilko Lake as far as the upper Tchaikazan valley. A number of mineral occurrences in the Tchaikazan valley, and the Pellaire gold occurrence to the south, occur close to granodiorite contacts. No roof pendants within the Coast Complex were noted during brief reconnaissance surveys of the creeks along the southern border of the map area, however, a pendant is mapped at the head of Norrington Creek by Cummings (1939).

Tipper (1978) has indicated Late Cretaceous and Eocene ages for intrusive rocks in this part of the Coast plutonic



CHILKO
LAKE
TASEKO
LAKES
Franklyn Arm
TCK
STK
TCK
124° 00'
51° 15'
51° 15'
51° 00'
N
0
5
KILOMETRES
Normal faults
Transcurrent faults;
TCK – Tchaikazan fault zone
STK – Stikelan fault zone
Thrust faults
Synform axis (showing direction of plunge)

Figure 9. Major structural elements of the Chilko Lake Planning Area.

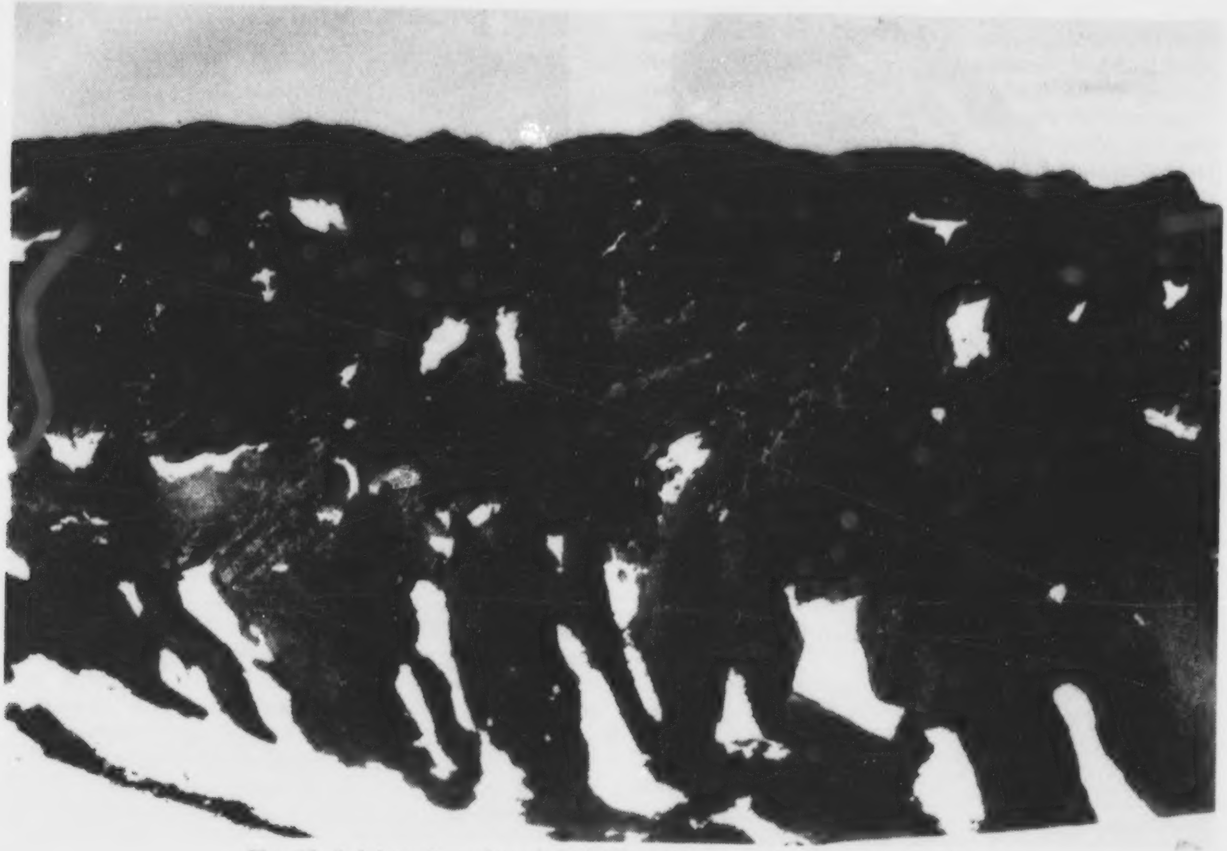


Plate 12. Imbricate thrust sheets in Unit LK_q sediments, east of Mount Dartmouth.

Plate 13. Asymmetric dragfolds associated with thrusting at the toe of Hamilton Glacier (Mount Dartmouth in background).

complex; this is also apparent in this study as these rocks cut most of the Lower Cretaceous stratigraphy. Wanless *et al.* (1964) record a Paleocene to Eocene age (56 ± 8 Ma) from biotite granite near the southern boundary of the map area. A potassium-argon date of 86.7 ± 2.6 million years on biotite from fresh granodiorite is reported by McMillan (1976) from the Taseko valley immediately east of the study area.

UNIT D — DIKES

A variety of narrow dikes are present in the map area, but are too small to plot on a regional map. The most common are mafic feldspar porphyries, probably of subvolcanic origin, that often have nodular or spherulitic textures developed along chilled margins. Pale grey, fine-grained, feldspar and carbonate-rich dikes and biotite or hornblende-rich lamprophyre dikes are also present. Brown-weathering carbonate alteration zones may be associated with any of these dikes.

STRUCTURE

The structural geology of the area is dominated by a series of northwest-trending transcurrent fault zones that are composed of numerous subparallel breaks with splays between them. Displacements, where apparent, are right-lateral; high-angle reverse movements are visible in some locations. Figure 9 outlines the major structural elements of the area. The northwest-trending Yalakom fault, with an inferred displacement of 150 kilometres (Kleinspehn, 1985), lies 15 kilometres north of the map area.

Plate 14. Massive volcanics of Unit LK_v thrust over interbedded sediments and volcanics of Unit LK_{TC} below Mount Goddard.

West of Chilko Lake two major structural zones, referred to as the Tchaikazan and Stikelan faults by Tipper (1969), are present on either side of the massive volcanics of Unit LK_{pv}. Although the Tchaikazan fault zone was only mapped on the upper slopes above Chilko Lake, it is likely that it extends beneath the lake and may be in part responsible for the slight northwesterly bend in the lake between Mount Goddard and Stikelan Pass. East of the lake the structures continue but do not define two separate zones. The Tchaikazan fault is poorly exposed east of the lake but is clearly present, based on the juxtaposition of rock units in the Yohetta valley. West of the lake intense shearing in carbonaceous argillites, and fracturing in volcanics, occur in canyons on lower Tredcroft Creek, and prominent zones of pervasive orange-weathering carbonate alteration containing strongly silicified fractures are seen farther northwest near Alexis Creek. Multidirectional slickensiding is characteristic of this zone; as many as five slickenside directions can be seen on a single hand specimen. Dioritic intrusions have invaded the zone and epithermal copper-mercury mineralization is apparent in a number of locations. Tipper (1969) suggested that this fault may have in excess of 30 kilometres of right-lateral displacement along it.

Plate 15. Northwest-trending fault zone on the south side of Yohetta valley. Arrows indicate movement of down-dropped blocks (looking southeast from Mount Goddard across Dorothy Lake).

Through most of the map area the Tchaikazan fault separates Upper Cretaceous rocks to the northeast from older lithologies to the southwest. The fault sliver (?) of Jurassic rocks in the Yohetta valley also suggests considerable displacement; similar Jurassic rocks occur 30 kilometres to the northwest along the fault zone. Monger (1986) has suggested that the Tchaikazan fault may be a segment of an extensive structural zone that includes the Bralorne fault to the south, and the Ross Lake fault in the Methow trough. Glover and Schiarizza (personal communication, 1988) trace this fault east of Taseko Lakes to a point where it is truncated by an intrusive of the Coast plutonic complex that has been dated at 86.7 ± 2.6 Ma (McMillan, 1976), placing a constraint on the most recent movement on the fault.

The Stikelan fault zone trends across Franklyn Arm to the headwaters of Stikelan Creek. Here argillaceous rocks are intensely foliated and locally contorted into tight irregular minor folds. A large section of rocks north of Tredcroft Creek has been steeply overturned along the fault zone, possibly in conjunction with thrusting from the southwest.

Thrust faults with a general northeasterly motion are present in a number of locations across the map area. Multiple northeasterly facing thrust faults are clearly evident in the well-bedded sediments of Unit LK_q to the south of Tredcroft Glacier. Stacked thrust sheets with spectacular recumbent asymmetric folds (Plates 12 and 13) attest to considerable stratigraphic shortening in this area. In the Mount Goddard area, massive volcanics of Unit LK_v have been thrust northeastward over volcanics and sediments of Unit LK_{TC} (Plate 14). The intrusive stock and dikes at Mount Goddard cut the thrust fault. Ammonites in Unit LK_{TCs} adjacent to this fault suggest the thrusting took place after the early Albian.

A large fault parallels the Tchaikazan fault south of the Yohetta valley and breaks into multiple splays in the Tchaikazan valley. This zone forms a prominent scarp along the ridge crest south of Yohetta Lake (Plate 15). Offset of an argillite bed by 3 metres (Plate 16) and thrusting of Unit LK_{TC} over Unit LK_v near RCAF Peak (Plate 17) indicate compressional movements on high-angle reverse faults within this zone.

Plate 16. High-angle reverse fault truncating black argillaceous sediments; offset is 3 metres (photograph taken while standing on same bed on left side of the fault break).

Plate 17. High-angle reverse fault places steeply dipping volcanics and sediments of Unit LK_{TC} over gently dipping Unit LK_{pv} volcanics north of RCAF Peak.

North-northeasterly trending normal faults form prominent lineaments on both landsat images (*see* frontispiece) and aerial photographs of the area. Prominent fractures in ridge crests, and silicified or quartz-carbonate-altered fault breccias attest to the presence of these faults on the ground. Northeasterly trending faults are evident in the Deschamps Creek – Franklyn Arm area and on Nine Mile Creek. These faults are responsible for the uplift and exposure of Triassic rocks in Deschamps valley. As they appear to cross the northwesterly trending structures with little displacement, they are considered to be younger. Tipper (1969) recognized similar northeasterly trending normal faults as late structural features to the west of the current map area.

Folds in the study area tend to be broad, open, southeasterly plunging structures. A large syncline dominates the area west of Chilko Lake between the two major fault zones. The fold trends across the lake and is seen again to the southeast where it is cored by younger(?) rocks of Unit LK_{TC}. A similar broad syncline occurs farther north within the volcanics of Unit UK_v; its closure was not mapped but is clearly visible in bedded strata east of Chilko Lake (compare Tipper, 1969).

Minor folds with tighter closures are locally present in the map area, but tend to be sheared out parallel to axial planes. Southwest of Spectrum Peak, a distinct anticline-syncline pair that is cut by a shear zone illustrates this structural style.

The structural evolution of the area is related to Middle to Late Cretaceous uplift and closure of the Tyaughton trough in response to terrane collisions along the continental margin. Transcurrent fault displacements developed in the Albian or later, as the trough was compressed. Emplacement of Cretaceous intrusions in the Coast Complex led to northeasterly facing thrusting along some of these zones of weakness and the broad synformal warping of the area in general.

TECTONIC IMPLICATIONS

The relationships between the volcanic and sedimentary rocks of the Chilko Lake Planning Area and other island arc and basin-fill assemblages of southwestern British Columbia provide some constraints on the origin of terrane boundaries in the area.

Garver *et al.* (1988) have indicated that the Methow-Tyaughton sediments collected in an elongate basin that records the Jurassic-Cretaceous transition from fore-arc to collisional tectonics along the western margin of North America. Thick sections of Hauterivian and early Albian rocks represent rapid subsidence in the central basin and the development of an uplifted western margin due to the collision of Wrangellia (Insular Superterrane) with North America. Compressional movements on thrust faults dominated at this time, whereas transcurrent movements on strike-slip faults were more common during the post-Albian, however, components of both were active throughout.

Rocks of the Chilko Lake area fit this model well as they record evidence of emergence of a Hauterivian volcanic arc that persisted until the Albian and interfingered with basinal sedimentation to the east. Westerly derived conglomeratic sediments in the Chilko Lake area are dominated by quartz and chert clasts, supporting the contention that they are derived from an uplifted oceanic complex adjacent to the west (Bridge River/Hozameen Groups; Garver *et al.*, 1988). The lack of granitic clasts in Early Cretaceous coarse sediments suggests that the Coast plutonic complex was not yet exposed near this area. Both high-angle reverse and strike-slip movements are evident on the major faults. Thrust faulting also appears related to emplacement of the Coast Complex.

The correlation of these volcanics with other pendants of similar age in southwestern British Columbia suggests that the Early Cretaceous island arc and basinal lithologies form an overlap assemblage marking the accretion of the Insular Superterrane with the Intermontane Superterrane. Should the correlation of the Mount Moore volcanics with rocks of Stikinia Terrane (Rusmore and Woodsworth, 1988) prove valid, the angular unconformity of Unit LK_s on Unit UT_V confirms an overlap of basinal rocks on the Intermontane Superterrane. Overlap of the Lower Cretaceous rocks on Insular Superterrane is not, however, clearly documented. Rocks of the Gambier Group correlative with strata of the Chilko Lake area have previously been suggested to overlie the Insular Superterrane (Monger, 1986). The precise location of the suture zone between the terranes remains unknown.

CHAPTER 3

GEOCHEMISTRY

INTRODUCTION

Early prospectors quickly learned that the geological environment of most mineral deposits contains diagnostic features that indicate their presence and that recognition of these indicators could lead them to an orebody. In most cases these indirect indicators extend over an area considerably larger than the orebody itself and therefore provide a larger 'needle' to search for in the 'geologic haystack'. Streams eroding a mineralized environment will contain anomalously high levels of indicator and ore elements in their sediments. Detection of these geochemical "anomalies" identifies prospective drainage basins (haystacks) where there is a greater potential for discovering orebodies (needles). Further detailed stream sediment and rock-chip sampling (lithogeochemistry) allows the tracing of geochemical indicators to their bedrock source.

An indicator or 'pathfinder' element is not necessarily an element of economic interest in the orebody being sought. In many gold-bearing veins elements such as mercury, arsenic or antimony are distributed in measurable amounts over a much larger area than the gold itself; increased levels of barium, tin, arsenic or a variety of other elements are often associated with copper-lead-zinc orebodies. These pathfinder elements may be distributed both laterally and vertically away from the actual orebody, and provide a relatively large target on which to focus exploration. Knowledge of these geochemical "signatures" has been built up over the years as models of the genesis of mineral deposits (metallogenic models) have been developed. These models will be discussed in more detail in Chapter 4. Regional and detailed geochemical surveys can provide evidence of economic mineralization in a region by determining the distribution patterns of indicator elements.

Stream-sediment geochemical surveys have become a routine component in many mineral exploration programs. Many government agencies also conduct regional geochemical surveys to determine areas of anomalously high metal values that are of significance in mineral exploration. The British Columbia Geological Survey Branch, in cooperation with the Geological Survey of Canada, has supported such a program since the mid-1970s; currently approximately 40 per cent of the province has been covered by this program. The main purpose of these reconnaissance geochemical surveys is to evaluate a region and focus the attention of the mineral industry on the most prospective areas.

Statistical manipulation of geochemical data obtained in these surveys allows the definition of threshold values that segregate a population of anomalously high values (possibly derived from mineralization) from background populations (those values occurring naturally throughout the unmineralized rock sequences). Interpretation of these data, in conjunction with geological mapping, provides targets for systematic exploration based on metallogenic models.

The Chilko Lake Planning Area is ideally suited to geochemical prospecting due to its physiography, large size, and known variety of mineral deposits. Government sponsored regional geochemical surveys have been conducted in the area east of Chilko Lake (British Columbia Ministry of Energy, Mines and Petroleum Resources, 1979, 1981). These surveys are not sufficiently detailed for mineral resource assessment purposes, therefore a detailed stream-sediment survey was undertaken in this project in order to evaluate the drainage geochemistry of the entire study area. Sampling density was greatest within the area perceived to have a higher mineral potential, that is, within the volcanic and sedimentary succession and along the contact zone of the Coast plutonic complex (Figure 10).

Data from two stream-sediment geochemical surveys conducted by industry and covering large parts of the study area (Assessment Reports 8295, 9023) are also publicly available (Figure 11).

Eleven zones within the planning area have been identified as having a higher mineral potential based on stream-sediment geochemical anomalies determined in this project (*see* Figure 16 and Table 5). The stream-sediment survey detected and characterized vein, porphyry and skarn mineralization previously known in the area and results suggest the presence of unexplored extensions to the known mineralization. Elsewhere geochemical anomalies unrelated to known mineralization are evident in areas of favourable geology, suggesting a good potential for discovery of new mineral showings and the need for further prospecting. Gold, arsenic, mercury, copper and lead have been found to be the most discriminating elements in identifying mineralized zones.

Stream-sediment geochemical data have also proved to be useful in defining distinct geochemical characteristics of some of the geological map units and have been of value in supporting the geological mapping and stratigraphic interpretations.

Rock-chip samples were also collected during the course of geological mapping as zones of mineralization or zones of alteration potentially related to mineralization were encountered. Anomalously high metal values detected in these samples provide more direct clues to the possible location of ore deposits. Detection of pertinent indicator elements within specific geologic environments reinforces the confidence with which certain metallogenic models can be applied to the area and provides further direction for exploration.

Rock-chip samples were coded according to the geologic environment at the sample site. Three different metallogenic environments are represented: the first is related to the granitic intrusive rocks, the second to the major fault zones and the third reflects mineralizing events contemporaneous with the formation of the volcanic and sedimentary rocks. Mineralization in Categories 1 and 2 is superimposed on the surrounding hostrocks and therefore is younger than mineral-

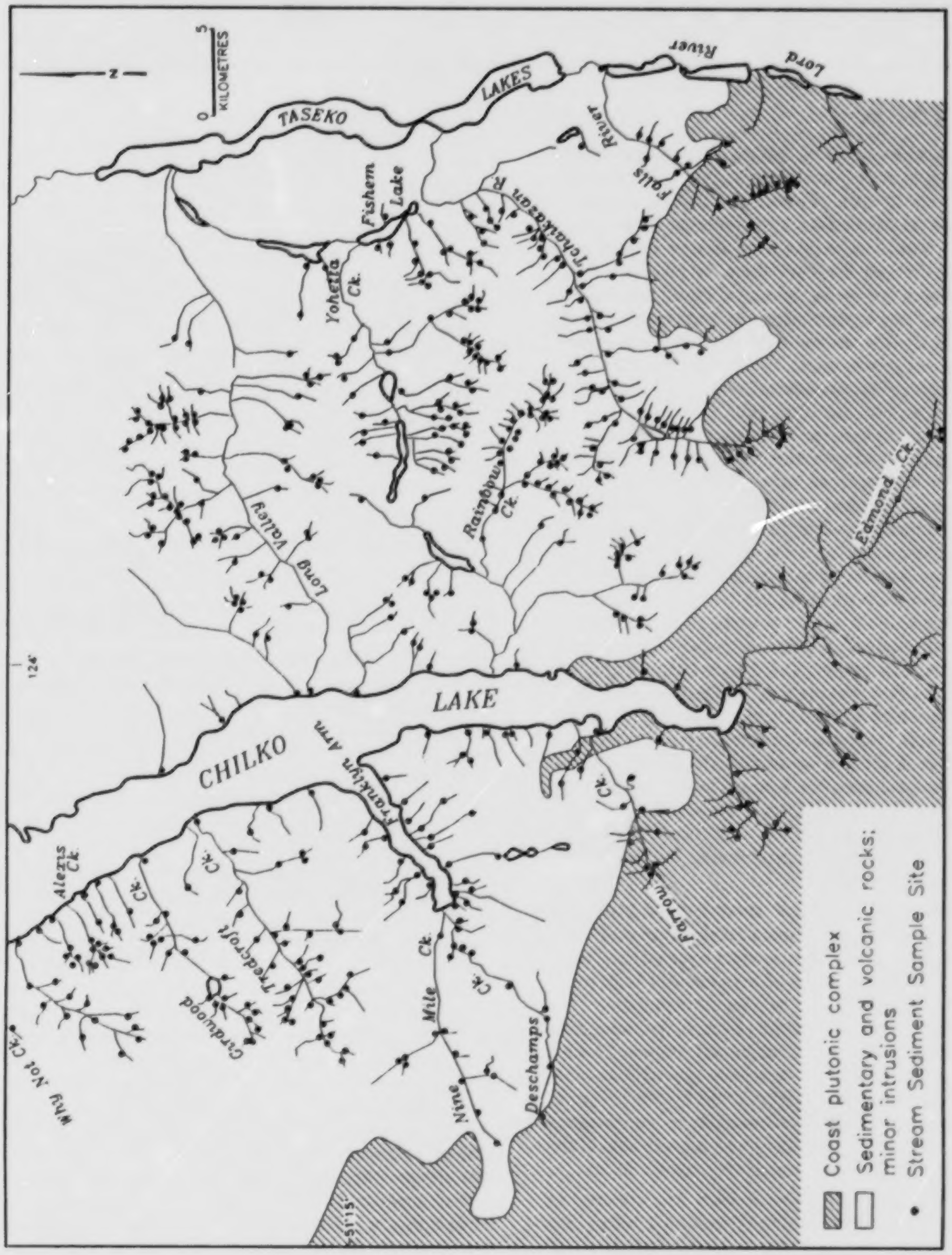
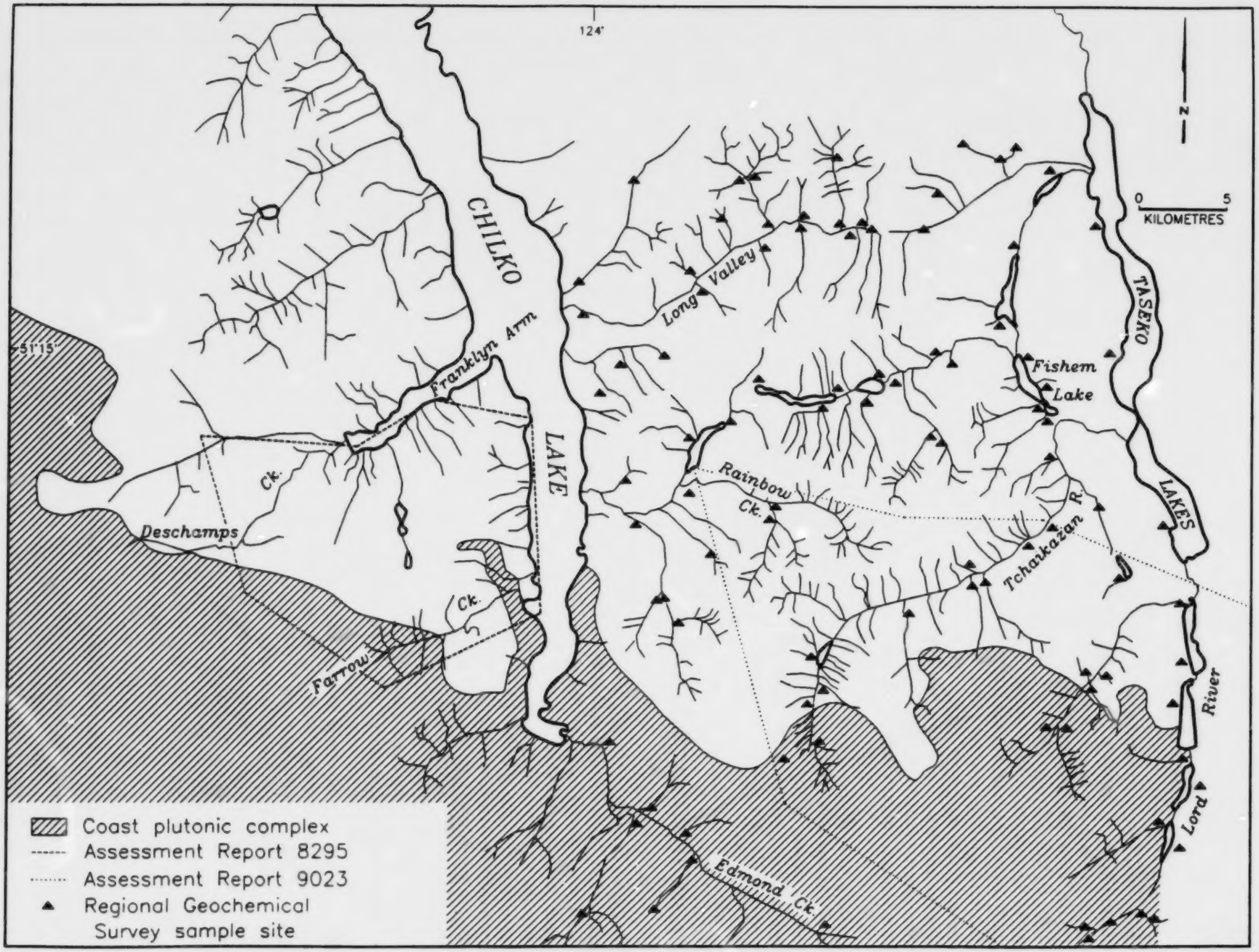

TASEKO
LAKES
N
0
5
KILOMETRES
River
Lord
Fishem Lake
Yohetta Ck.
Tchaikazan R.
Falls
River
Rainbow Ck.
Long Valley
Edmond Ck.
124°
CHILKO
LAKE
Franklyn Arm
Alexis Ck.
Ck.
Ck.
Tredcroft
Cordwood
Why Not Ck.
Nine Mile Ck.
Deschamps Ck.
Farrow Ck.
Ck.
51°15'
▨ Coast plutonic complex
☐ Sedimentary and volcanic rocks; minor intrusions
● Stream Sediment Sample Site

Figure 10. Stream-sediment sample site locations.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KILOMETRES
CHILKO
LAKE
TASEKO
LAKES
Franklyn Arm
Long Valley
Fishem Lake
Rainbow Ck.
Tchaikazan R.
River
Lord
Deschamps Ck.
Farrow Ck.
Edmond Ck.
▨ Coast plutonic complex
------ Assessment Report 8295
.... Assessment Report 9023
▲ Regional Geochemical Survey sample site

Figure 11. Locations of previous geochemical survey data.

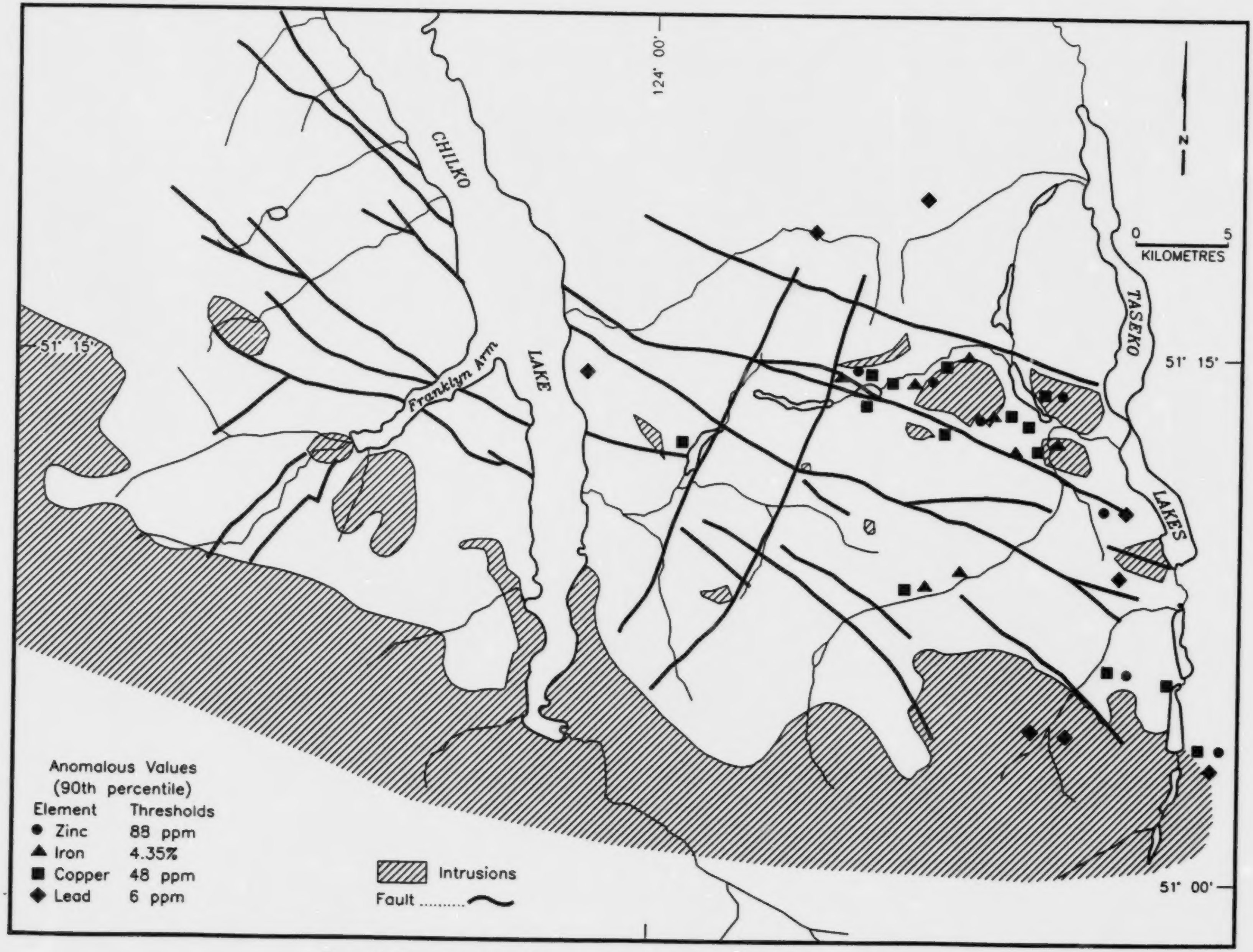
124° 00'
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
N
0
5
KILOMETRES
51° 15'
51° 15'
51° 00'
Anomalous Values
(90th percentile)
Element Thresholds
● Zinc 88 ppm
▲ Iron 4.35%
■ Copper 48 ppm
◆ Lead 6 ppm
Intrusions
Fault ....

Figure 12. Regional geochemical survey data – anomalous copper, zinc, iron and lead values.

ization in Category 3. The different metallogenic environments are characterized by different suites of metals present (*see* Table 8), hence these data are of great value in defining the nature of the metallogenic processes active throughout the geologic history of the Chilko Lake Planning Area.

Lithogeochemical data identify numerous zones considered to have a higher mineral potential. These data confirm published metal values from known mineral occurrences and identify new areas of mineralization. These zones of higher mineral potential often overlap with the 11 zones of higher mineral potential defined by the stream-sediment data.

PREVIOUS WORK

Anomalously high metal values detected by previous geochemical surveys have clearly identified two distinct zones of higher mineral potential: the zone between the Falls and Tchaikazan rivers, and a fault-bounded zone extending from Taseko Lake to the Yohetta valley. Other isolated anomalies, including those in the vicinity of Franklyn Arm, are of undetermined significance.

The area east of Chilko Lake was sampled by a Regional Geochemical Survey (RGS) program conducted in the area covered by map sheets 92O and 92P in 1979; areas of similar geology east of Taseko Lake were also covered. Ninety-eight samples were collected within the study area. These surveys are regional in nature; with a sampling density averaging one sample site per 14 square kilometres, they provide baseline information to the exploration industry. Stream-sediment samples were sieved to -80 mesh (<177 microns) and subsequently analyzed for zinc, copper, lead, nickel, cobalt, silver, manganese, iron, arsenic, molybdenum, tungsten, mercury and uranium; water samples collected at each site were analyzed for uranium, fluorine and pH.

Within the Chilko Lake Planning Area the RGS data clearly outline a zone of elevated concentrations of zinc, copper, arsenic and iron, trending from the lower Tchaikazan valley to Yohetta valley. The highest values occur within the fault-bounded wedge of Upper Cretaceous sediments (Unit UK_5) and Eocene felsites (Figure 12). Arsenic and, to a lesser extent, mercury values follow the trend of the Tchaikazan fault between Taseko and Chilko lakes (Figure 13). This general northwesterly trend can be traced east of Taseko Lakes where polymetallic anomalies are more pronounced; the arsenic-mercury signature of the Tchaikazan fault is also present. Isolated copper, arsenic, zinc and lead anomalies also occur between the Tchaikazan and Falls rivers. The Chilko to Taseko Lakes area is unusually neutral in pH; a pocket of slightly acid stream waters is located east of Taseko Lakes, while most other streams in the 92O map area are somewhat alkaline.

In 1980 a regional stream-sediment and heavy-mineral survey was conducted along the periphery of the Coast Complex between Gold Bridge and Chilko Lake (Assessment Report 9023). Gold was the primary element sought. A total of 89 samples was collected from the Tchaikazan, Falls, Lord, and Rainbow drainages in the Chilko Lake Planning Area (Figure 14) and these were analyzed for gold, silver, arsenic, antimony, copper and lead.

The zone between the Falls and Tchaikazan rivers returned highly anomalous lead, copper and silver values (up to 3400 ppm, 600 ppm and 10 ppm respectively in heavy-mineral fractions: Figure 14). Anomalous levels of antimony were also obtained. Five claim groups were staked and briefly explored as follow-up to this survey, but no mineralization was found. Further discussion of this work is given in the Chapter 4.

Also in 1980, geochemical surveying was completed as part of a larger exploration program on claims near Franklyn Arm, west of Chilko Lake (Assessment Report 8295). Twenty-seven heavy-mineral samples were collected and analyzed for 13 elements (Au, Ag, Zn, Cu, Pb, Mo, Sn, W, Sb, Nb, Ce, Cr, F). Anomalous values in gold, tungsten and copper were reported from scattered locations (Figure 14), however, some of these were derived from extremely small sample fractions and may have been subject to sampling errors. Conventional sediment sampling conducted as follow-up did not confirm the heavy-mineral anomalies, however it did identify anomalous copper values in Deschamps Creek.

The study area was also geochemically surveyed by a number of companies during the 1960s and 1970s as part of regional evaluations of the eastern margin of the Coast Range. This work was aimed primarily at detecting porphyry copper-molybdenum deposits and the results are not publicly available.

STREAM-SEDIMENT GEOCHEMICAL SURVEY

The stream sediment geochemical survey conducted in this project covered an area of approximately 1800 square kilometres. All accessible drainage basins were sampled to obtain a broad spectrum of analytical data, with the specific aim of determining elements indicative of the expected styles of mineralization. Duplicate samples (1 in 20) were collected in the field; laboratory duplicates and reference materials were inserted during sample processing; the sampling and analytical procedures are described in Appendix A. Variances due to sampling and analytical procedures in this survey are low; precision is considered to be 10 per cent or less, an acceptable level for stream sediment exploration data (Figures A-1, A-2). Data variances introduced during sample preparation and analysis appear to be small, hence residual variances can be confidently attributed to geologic parameters. A total of 537 sites were sampled (Figure 10); sample density in the volcanic and sedimentary terrains averaged one site per 2.5 square kilometres. Samples were analyzed for 32 elements as shown in Table 2. Analytical data are provided in Appendix A and have been previously published, with element distribution maps, in two separate Open Files (McLaren 1986c, 1987c).

DATA INTERPRETATION

Initial visual evaluation of the data focused on elements pertinent to metallogenic models and on any elements that displayed a geographic control over distribution. This review indicated that 15 elements of interest provided sufficient data above detection limits for further detailed statistical treat-

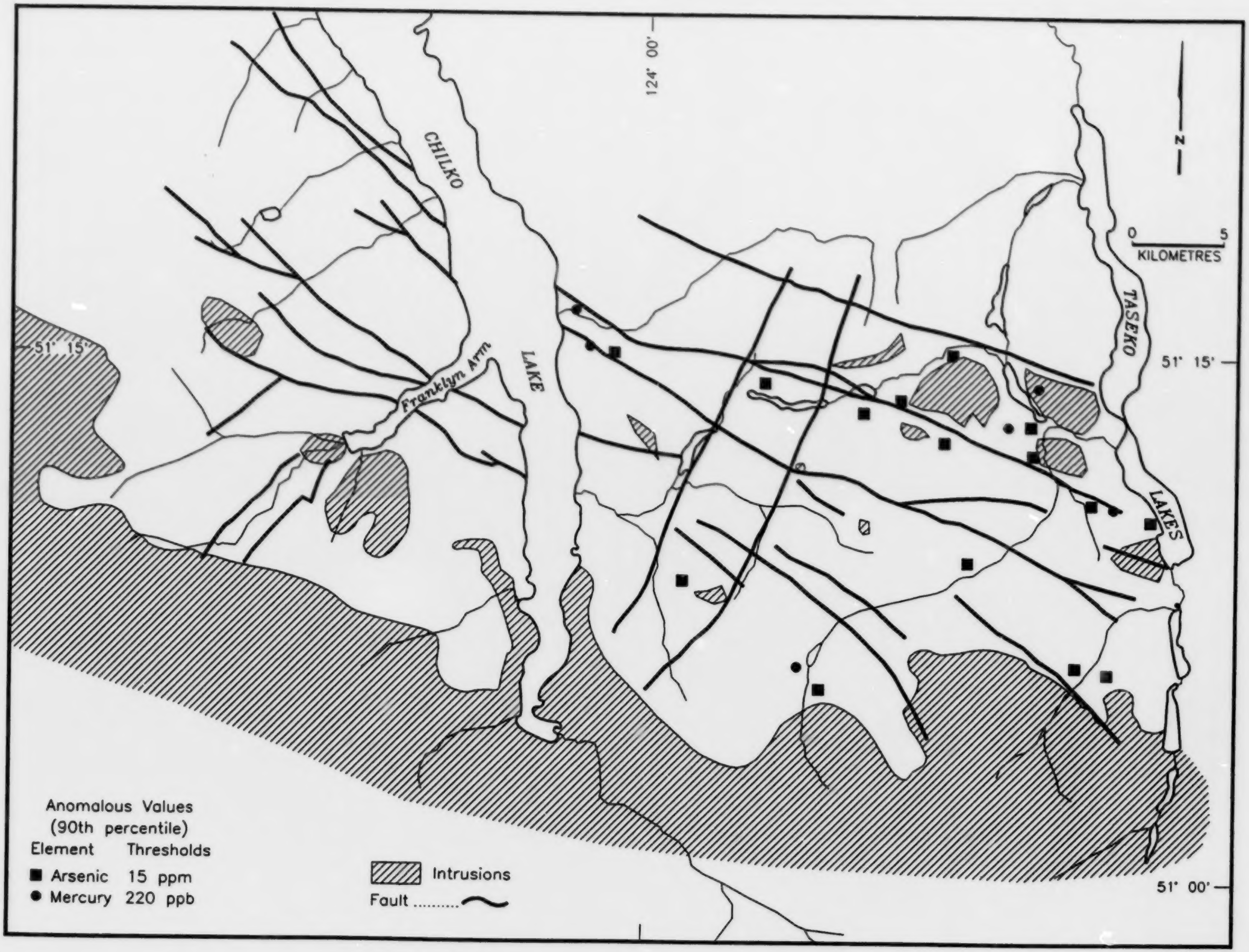
124° 00'
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
0
5
KILOMETRES
N
51° 15'
51° 15'
51° 00'
Anomalous Values
(90th percentile)
Element Thresholds
■ Arsenic 15 ppm
● Mercury 220 ppb
▨ Intrusions
Fault

Figure 13. Regional geochemical survey data – anomalous mercury and arsenic values.

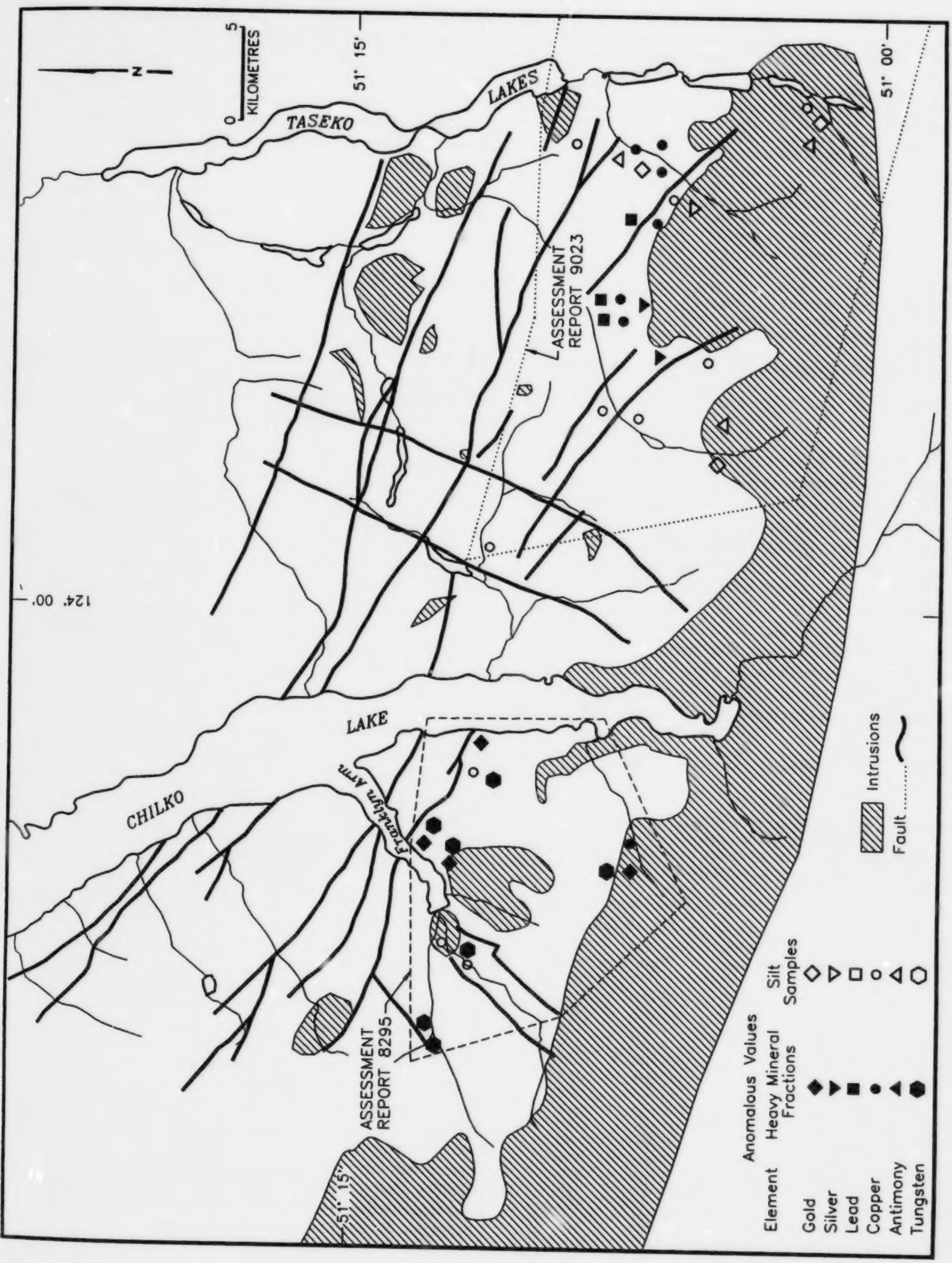
TASEKO LAKES
0 5 KILOMETRES
N
51° 15'
51° 00'
124° 00'
ASSESSMENT REPORT 9023
CHILKO LAKE
Franklyn Arm
ASSESSMENT REPORT 8295
51° 15'
Element
Anomalous Values
Heavy Mineral Fractions
Silt Samples
Gold
Silver
Lead
Copper
Antimony
Tungsten
Intrusions
Fault

Figure 14. Anomalous geochemical data from assessment reports.

TABLE 2
ANALYTICAL DETECTION LIMITS† FOR ELEMENTS DETERMINED IN THE STREAM SEDIMENT SURVEY

Element	Detection Limit	Element	Detection Limit	Element	Detection Limit
Gold	1 ppb	Iron	0.01 %	Beryllium*	0.5 ppm
Silver	0.2 ppm	Nickel	1 ppm	Calcium*	0.01 %
Mercury	5 ppb	Cobalt	1 ppm	Gallium*	10 ppm
Arsenic	10 ppm	Cadmium	0.5 ppm	Lanthanum*	10 ppm
Antimony	10 ppm	Chromium*	1 ppm	Magnesium*	1 ppm
Bismuth	2 ppm	Strontium*	1 ppm	Phosphorus	10 ppm
Copper	1 ppm	Titanium*	0.01 %	Potassium*	0.01 %
Zinc	10 ppm	Vanadium	10 ppm	Sodium*	0.01 %
Lead	2 ppm	Tungsten*	10 ppm	Thallium*	10 ppm
Manganese	1 ppm	Uranium	10 ppm	Aluminum*	0.01 %
Molybdenum	1 ppm	Barium*	10 ppm		

* The nitric acid/aqua regia digestion used is possibly incomplete for these elements.

† published detection limits from commercial geochemical laboratory

ment, as discussed below. Individual high values for elements that were below the detection limit in most samples (*e.g.*, Ag, Mo) will be discussed where appropriate. These analytical data were separated into two groups based on the geologic provenance of the samples. Four hundred and sixty-two samples obtained from drainage basins mainly underlain by volcanic and sedimentary lithologies displayed consistently higher mean values than the 75 samples taken from streams draining rocks of the Coast plutonic complex (Table 3). Even though there is considerable variability within these two data populations the distinctly higher values determined from the volcanic and sedimentary terrains support this initial segregation into two separate populations.

TABLE 3
MEAN VALUES AND COEFFICIENTS OF VARIANCE OF SAMPLE POPULATIONS: VOLCANIC AND SEDIMENTARY VERSUS COAST PLUTONIC LITHOLOGIES

	Volcanics — Sediments N = 462		Coast Plutonic Complex N = 75	
Element	Geometric Mean	Coefficient of Variance	Geometric Mean	Coefficient of Variance
Gold	1.2 ppb	633%	1.1 ppb	901%
Arsenic	10 ppm	43%	5 ppm	40%
Barium	88 ppm	13%	51 ppm	17%
Cobalt	17 ppm	12%	6 ppm	35%
Chromium	32 ppm	17%	20 ppm	24%
Copper	41 ppm	13%	15 ppm	35%
Iron	4.6 %	19%	2.7 %	44%
Lead	2.5 ppm	114%	2.0 ppm	131%
Mercury	82 ppb	23%	27 ppb	15%
Manganese	728 ppm	5%	274 ppm	9%
Nickel	21 ppm	21%	6 ppm	47%
Strontium	76 ppm	15%	31 ppm	15%
Titanium	0.13 %	45%	0.09 %	16%
Vanadium	103 ppm	10%	63 ppm	13%
Zinc	73 ppm	9%	26 ppm	21%

Histograms and cumulative probability plot analysis of each data population (Sinclair, 1976) provide a reasoned method of partitioning data into distinct subpopulations and give information on each subpopulation in terms of its mean, standard deviation, and degree of overlap with neighbouring populations. All of the data except nickel partition into either unimodal or bimodal distributions; the nickel results have a trimodal distribution.

Subpopulations, attributed to anomalously high values reflecting a specific geologic process (mineralizing events, a particular geologic horizon) versus background values normally found throughout the area, were interpreted for each element. Threshold values segregating "anomalous", "possibly anomalous" (zone of overlap between lower anomalous and higher background data) and "background" portions of the subpopulations were determined after studying their distribution and degree of overlap. Threshold levels were chosen from the subpopulations using the mean plus 2 standard deviations to define anomalous and possibly anomalous values in overlapping populations. In unimodal distributions the mean plus 2 standard deviations identified anomalous data and the mean plus 1.5 standard deviations identified possibly anomalous data. Table 4 summarizes the population parameters and threshold values determined for data from drainage basins underlain by volcanic and sedimentary lithologies. Figure 15 (a through o) illustrates the probability plots. Further interpretation of stream-sediment survey results will be restricted to data derived from the volcanic and sedimentary succession. Data from the Coast plutonic complex tends to be uniformly low for all elements; visual evaluation indicates no distinctive anomalies exist as the absolute values are generally not of significant interest, there is no clustering of any higher values, and there are no clear associations evident between elements. For this reason, and because this area is perceived to be of lower mineral potential, no discussion of results from this area is given. Individual higher values from the Coast Complex will be included with those from volcanic and sedimentary lithologies in the following discussion.

RESULTS

As outlined in the introduction to this chapter, the stream-sediment geochemical survey sucessfully identified known mineralization in the study area and identified 11 zones with a higher mineral potential. The survey also contributed to the discovery of a new mineral occurrence (Twin Creek). Table 5 summarizes data from these zones and tabulates the pertinent geochemical indicators and favourable geological aspects of each area. In addition to identifying the most useful indicator elements, other element associations are apparent, such as the barium and nickel association with mercury in the Alexis area, that may prove useful in exploration. No attempt is made to rank the zones at this stage. Zones of greater mineral potential, shown on Figure 16, are described briefly in the following discussion. Figure 17 (a through o) illustrates the geographic distribution of anomalous values.

TABLE 4
POPULATION PARAMETERS AND THRESHOLD VALUES FOR STREAM SEDIMENT DATA FROM VOLCANIC AND SEDIMENTARY LITHOLOGIES

Element	N*	Transform	Range	# of Populations	% in Population	Population Mean	Standard Deviation	Thresholds	
								Anomalous	Possibly Anomalous
Gold	462	L	1–850 ppb	1	100	0.6 ppb	−0.07 ppb +4.5 ppb	35 ppb	—
Arsenic	462	L	2–230 ppm	2	52	3.5 ppm	−2.2 ppm +5 ppm	91 ppm	65 ppm
					48	23 ppm	−11 ppm +46 ppm		
Barium	462	L	20–510 ppm	1	100	88 ppm	−48 ppm +158 ppm	288 ppm	214 ppm
Cobalt	462	A	10–43 ppm	2	93	17 ppm	±5 ppm	27 ppm	24 ppm
					7	26 ppm	±8 ppm		
Chromium	462	L	4–242 ppm	1	100	32 ppm	−18 ppm +58 ppm	103 ppm	77 ppm
Copper	458*	A	6–220 ppm	2	94	41 ppm	±13 ppm	68 ppm	55 ppm
					6	97 ppm	±21 ppm		
Iron	462	A	2.4–10.8%	2	95	4.6%	±1.1%	6.7%	6.1%
					5	7.6%	±1.0%		
Mercury	455*	L	20–2600 ppb	2	92.5	67 ppb	−34 ppb +131 ppb	260 ppb	242 ppb
					7.5	696 ppb	−410 ppb +1178 ppb		
Manganese	462	A	124–2749 ppm	2	91	727 ppm	±220 ppm	1167 ppm	1060 ppm
					9	1050 ppm	±360 ppm		
Nickel	462	A	2–112 ppm	3	84	20 ppm	±9 ppm	59 ppm	43 ppm
					10	50 ppm	±4 ppm		
					6	70 ppm	±13 ppm		
Lead	223†	L	1–50 ppm	2	98	6 ppm	−3 ppm +11 ppm	20 ppm	—
					2	33 ppm	−26 ppm +41 ppm		
Strontium	462	L	13–347 ppm	2	78	59 ppm	−37 ppm +94 ppm	152 ppm	124 ppm
					22	182 ppm	−150 ppm +221 ppm		
Titanium	462	A	0.05–0.71%	2	83	0.13%	±0.08%	0.29%	0.26%
					17	0.40%	±0.10%		
Vanadium	462	L	27–431 ppm	2	90	94 ppm	−65 ppm +135 ppm	196 ppm	168 ppm
					10	244 ppm	−203 ppm +294 ppm		
Zinc	462	A	30–206 ppm	2	88	69 ppm	±22 ppm	113 ppm	102 ppm
					12	122 ppm	±36 ppm		

* A few extremely high values have been omitted to aid interpretation of probability plots.

† Numerous values below detection limit have been omitted to aid interpretation of probability plots.

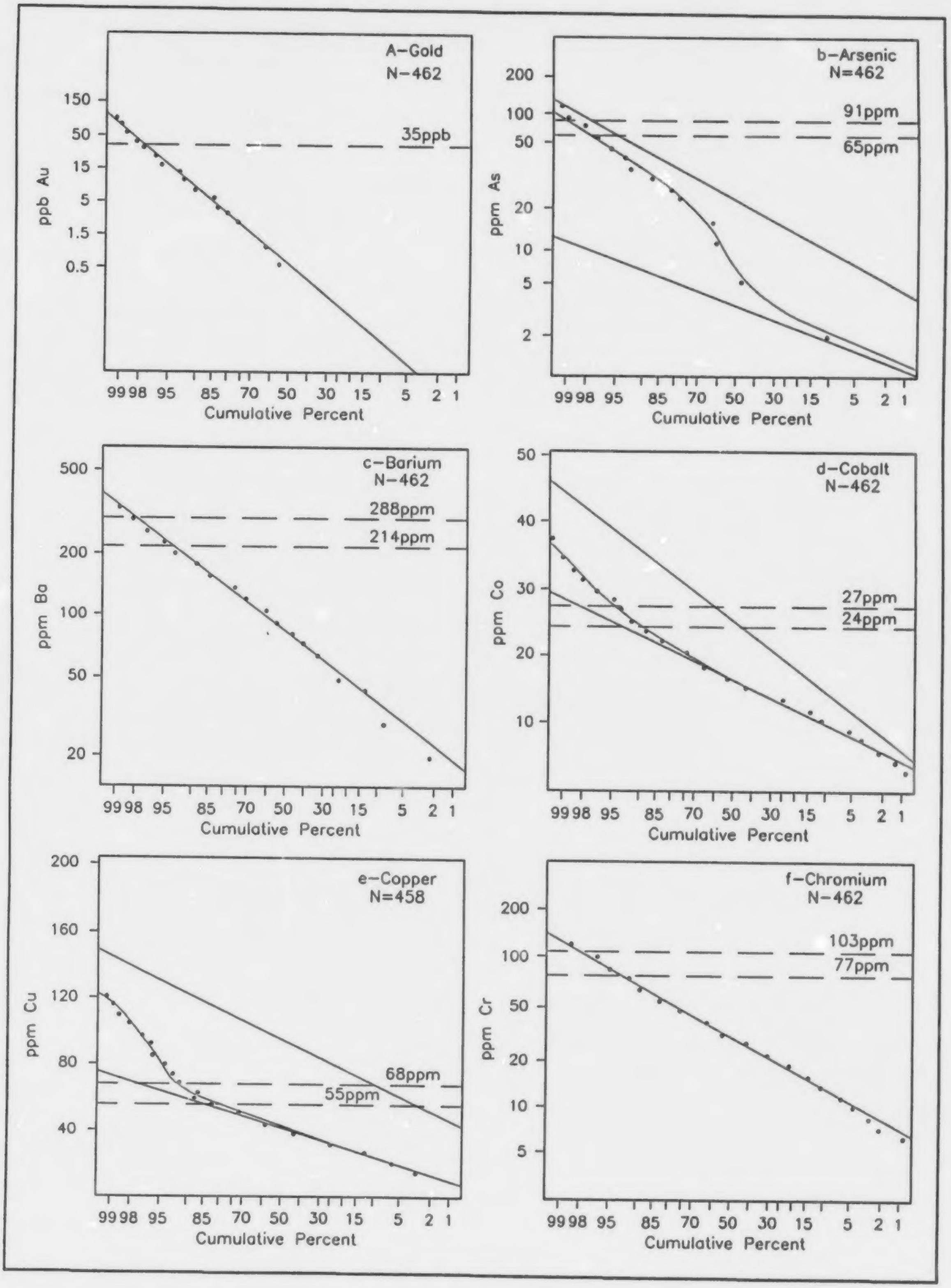

Figure 15. Probability plot analysis of stream-sediment data (a–f).

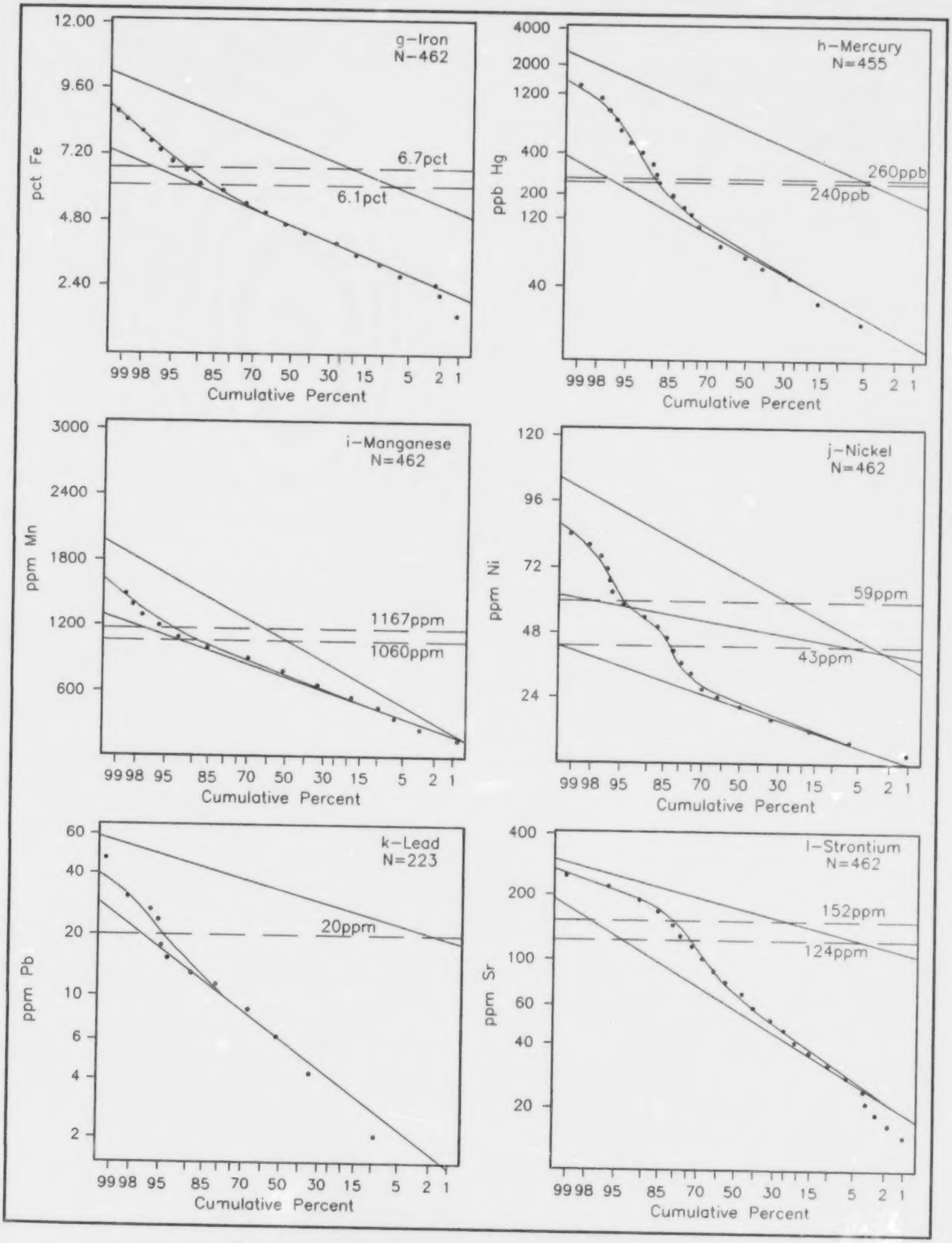

Figure 15. Probability plot analysis of stream-sediment data (g–l).

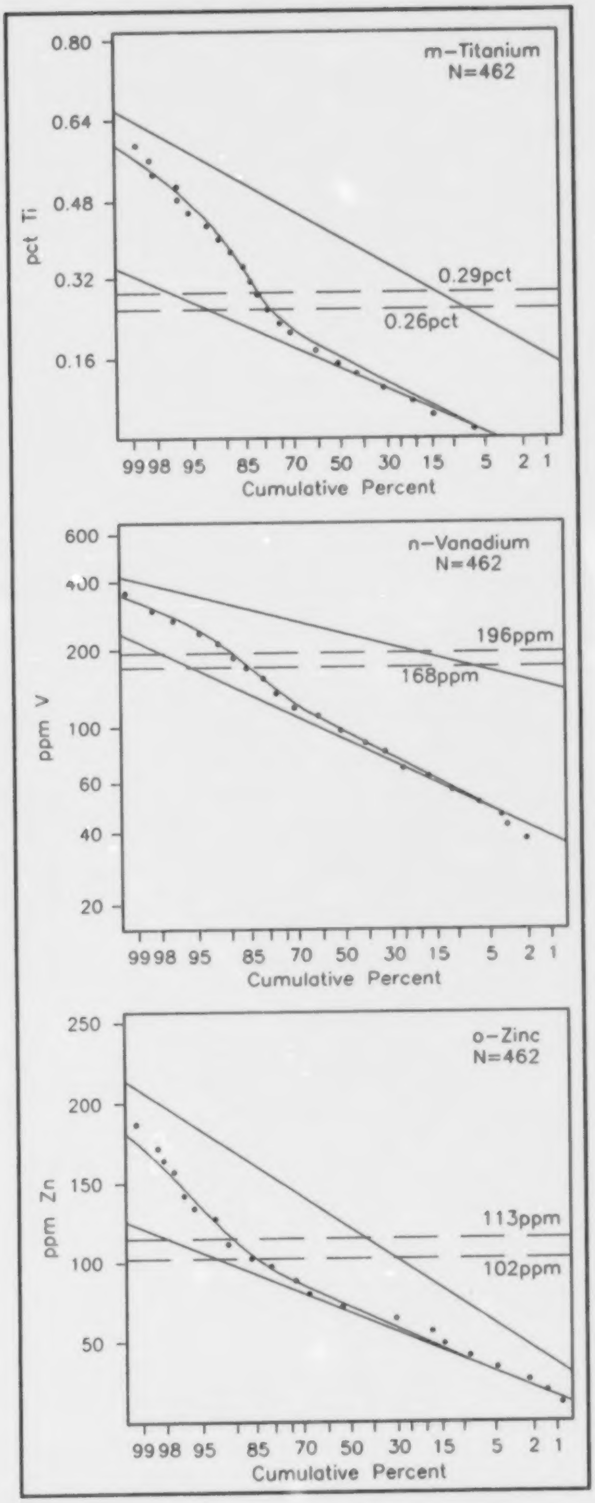

Figure 15. Probability plot analysis of stream-sediment data (m–o).

TABLE 5
SUMMARY OF ZONES OF GREATER MINERAL POTENTIAL BASED ON ANOMALOUS STREAM SEDIMENT GEOCHEMISTRY

Zone	Geochemical Indicators*	Favourable Geological Features
Alexis Creek (Tchaikazan fault zone)	1– Hg, Ba 2– Pb, Cu, Ni, Zn	faults, intrusive dikes, known mineralization
Charlie area	1– Cu, Au	faults, intrusive dikes, known mineralization
Yohetta (Fishem to Yohetta lakes)	1– Au, Hg, Ba 2– Ni, Zn, Cu	faults, intrusions
Taseko	1– As, Hg 2– Zn, Pb	faults, intrusions
Twin Creek (Tchaikazan to Falls River)	1– Au, As, Cu 2– Ba, Pb, Zn, Ag	faults, known mineralization
Mount Goddard	1– Cu, Pb, Zn 2– Hg, As	faults, intrusions, known mineralization
Tarn Creek	1– Cu, Mo	faults, intrusive dikes, known mineralization
Spectrum Peak	1– As, Hg, Ba 2– Cu, Pb, Zn 3– Sr	faults, intrusions
Daisie	1– Cu, Mo 2– As, Ba 3– Pb, Zn	faults, intrusions, known mineralization
Franklyn Arm	1– As, Hg, Cu	felsic volcanics, faults
Tredcroft Creek (Stikelan fault zone)	1– As, Cu, Pb	faults, intrusions

* Geochemical indicators are ranked according to their perceived usefulness and selectivity in identifying mineralization.

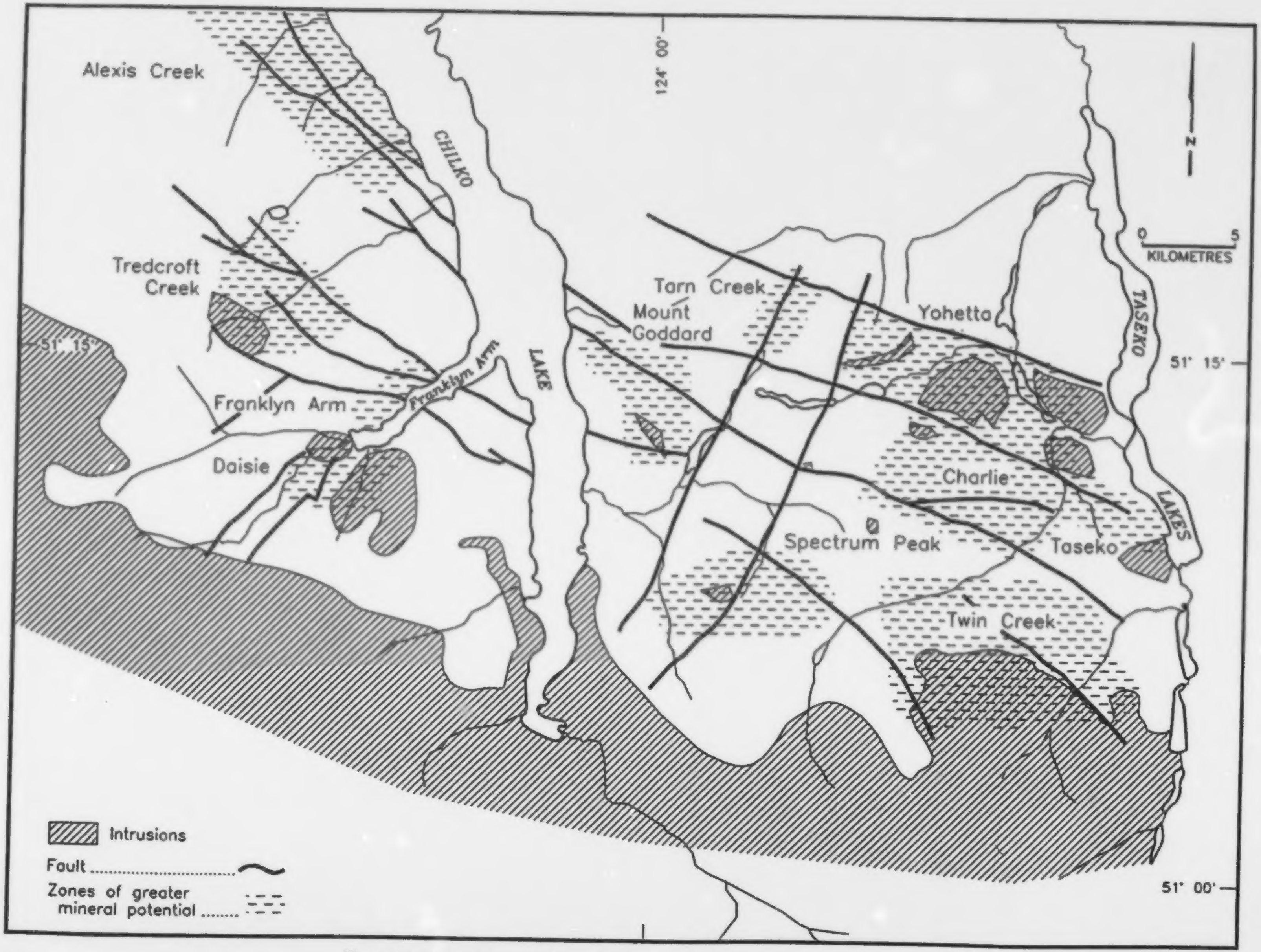
Alexis Creek
CHILKO
LAKE
124° 00'
Tredcroft Creek
Franklyn Arm
Franklyn Arm
Daisie
Tarn Creek
Mount Goddard
Yohetta
Charlie
Spectrum Peak
Taseko
Twin Creek
TASEKO
LAKES
N
0
5
KILOMETRES
51° 15'
51° 15'
51° 00'
Intrusions
Fault
Zones of greater mineral potential

Figure 16. Zones of greater mineral potential as defined by stream-sediment geochemistry.

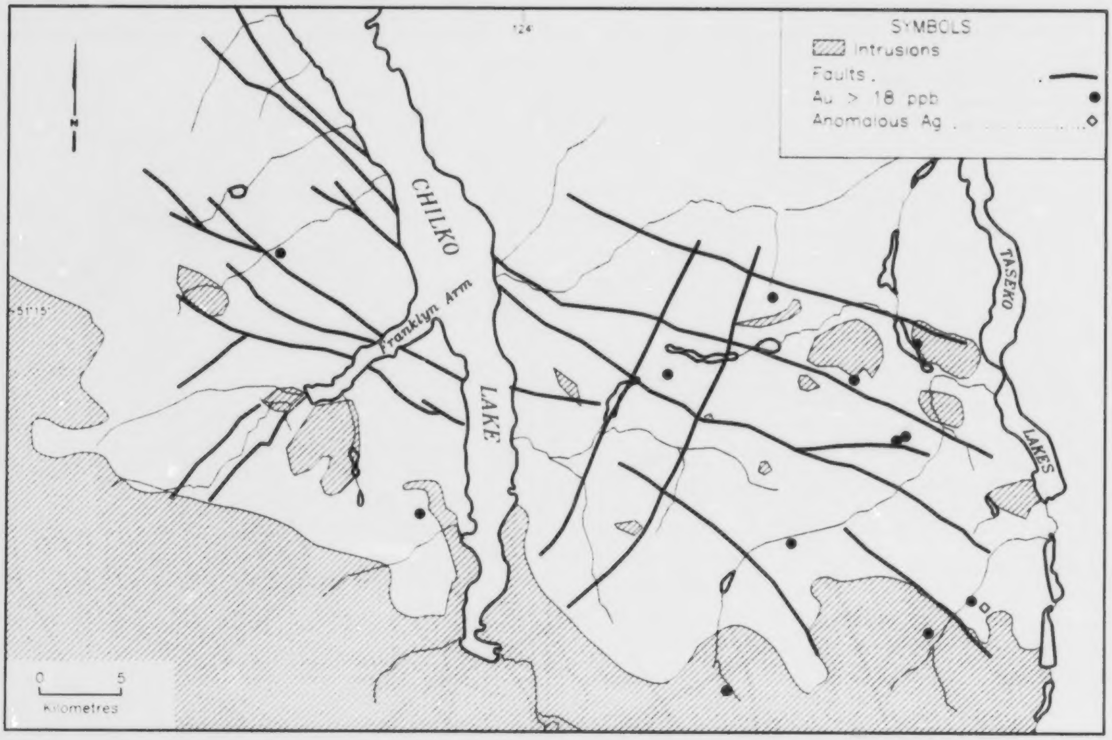
SYMBOLS
▨ Intrusions
Faults
Au > 18 ppb ●
Anomalous Ag ◇
124°
51°15'
N
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
0 5
Kilometres

Figure 17a.

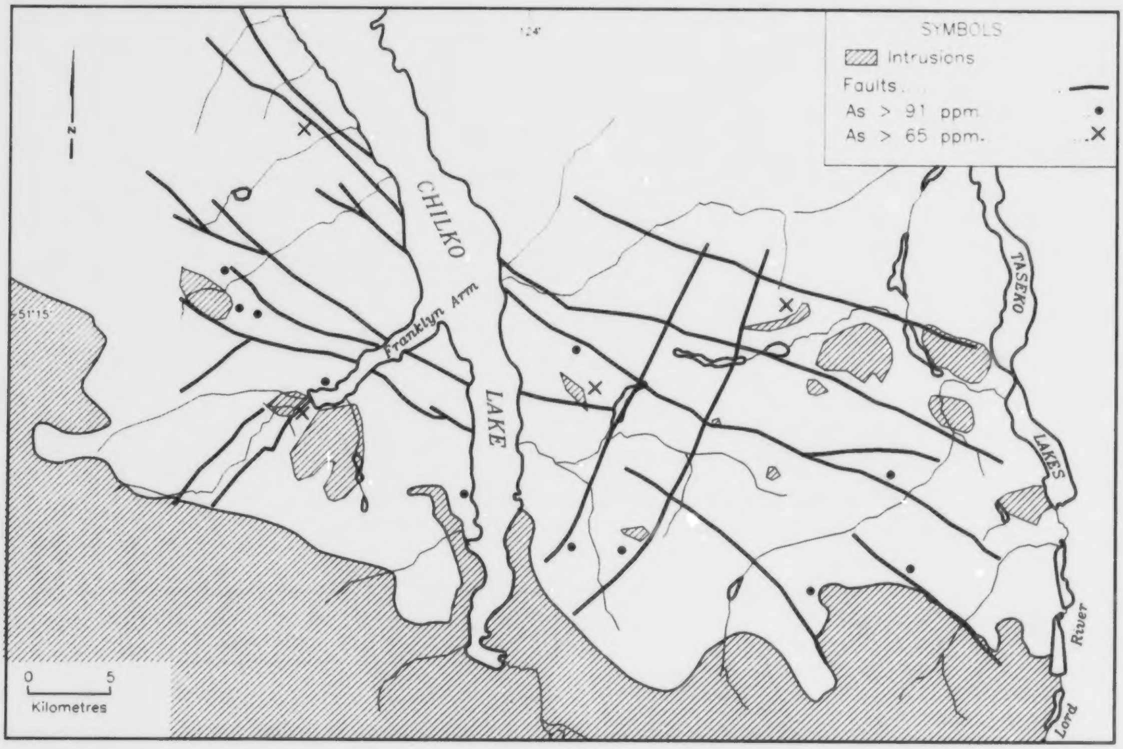
SYMBOLS
▨ Intrusions
Faults
As > 91 ppm ●
As > 65 ppm ✕
124°
51°15'
N
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
River
Lord
0 5
Kilometres

Figure 17b. Distribution of anomalous values in stream sediments.

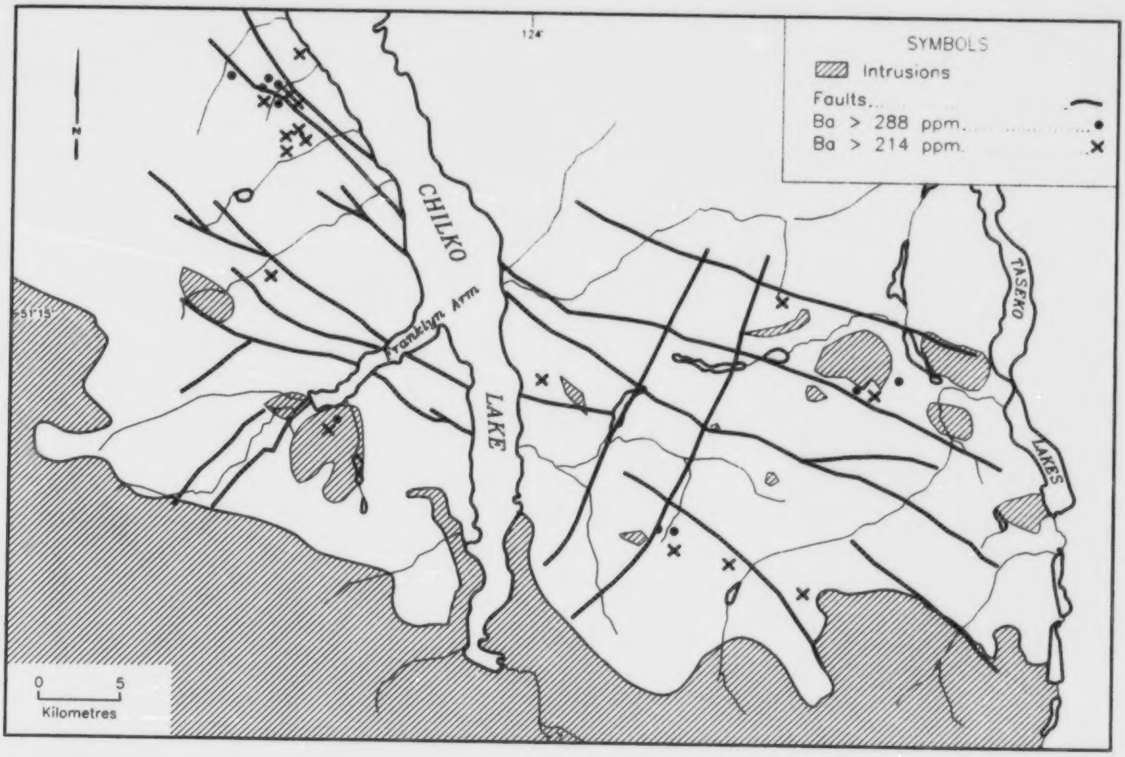
124°
SYMBOLS
▨ Intrusions
Faults
Ba > 288 ppm ●
Ba > 214 ppm ×
N
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
51°15'
0 5
Kilometres

Figure 17c.

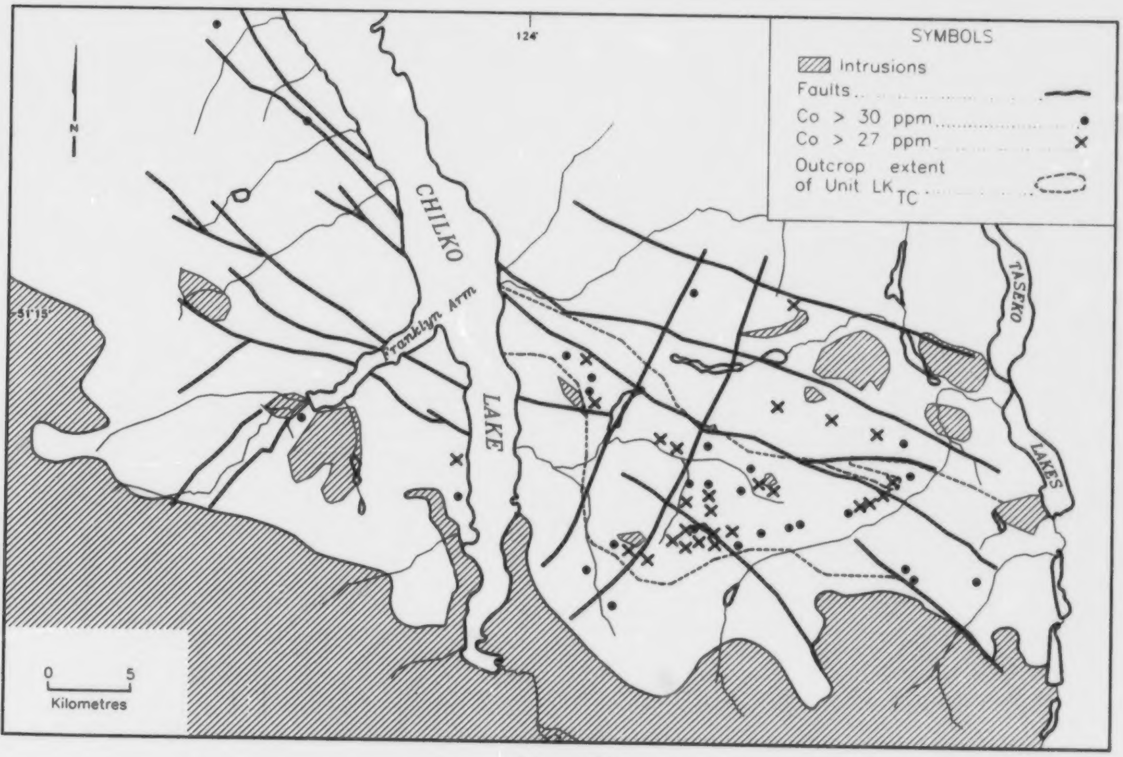
124°
SYMBOLS
▨ Intrusions
Faults
Co > 30 ppm ●
Co > 27 ppm ×
Outcrop extent of Unit LK$_{TC}$
N
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
51°15'
0 5
Kilometres

Figure 17d.

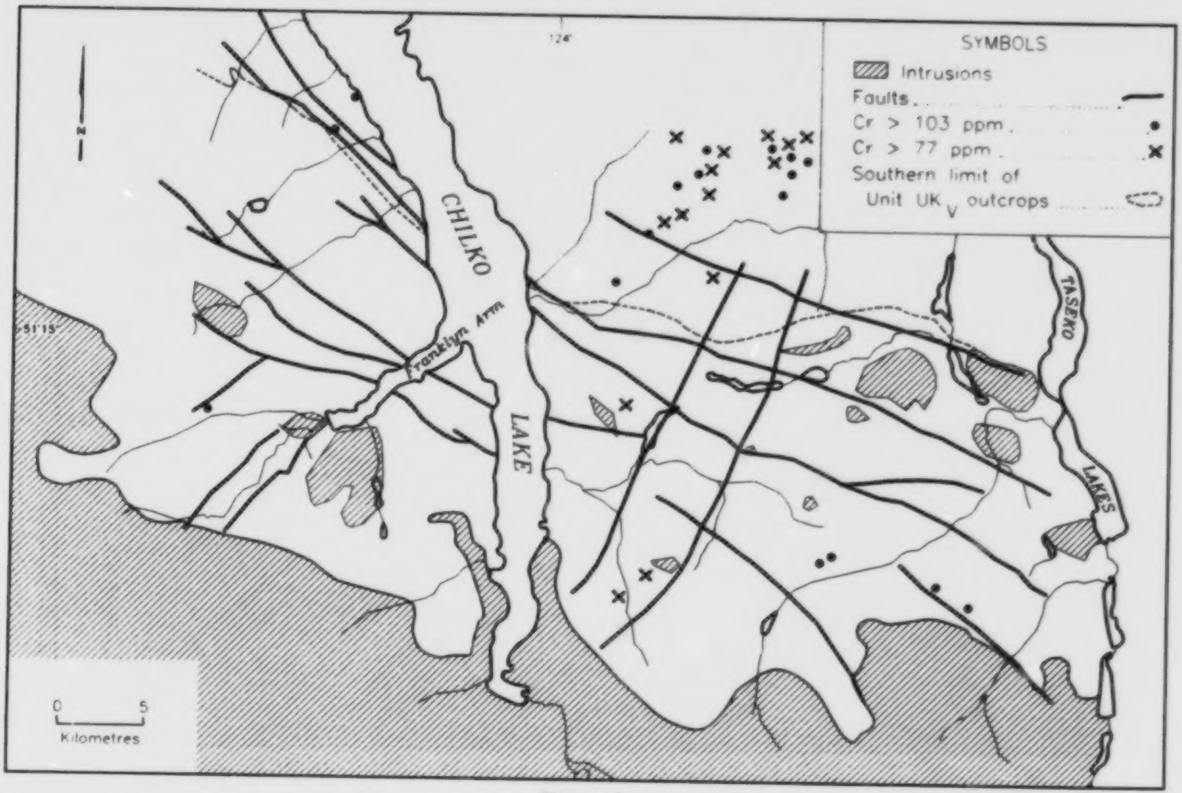
SYMBOLS
▨ Intrusions
Faults
Cr > 103 ppm ●
Cr > 77 ppm ×
Southern limit of Unit UK$_V$ outcrops
124°
51°15'
N
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
0
5
Kilometres

Figure 17e.

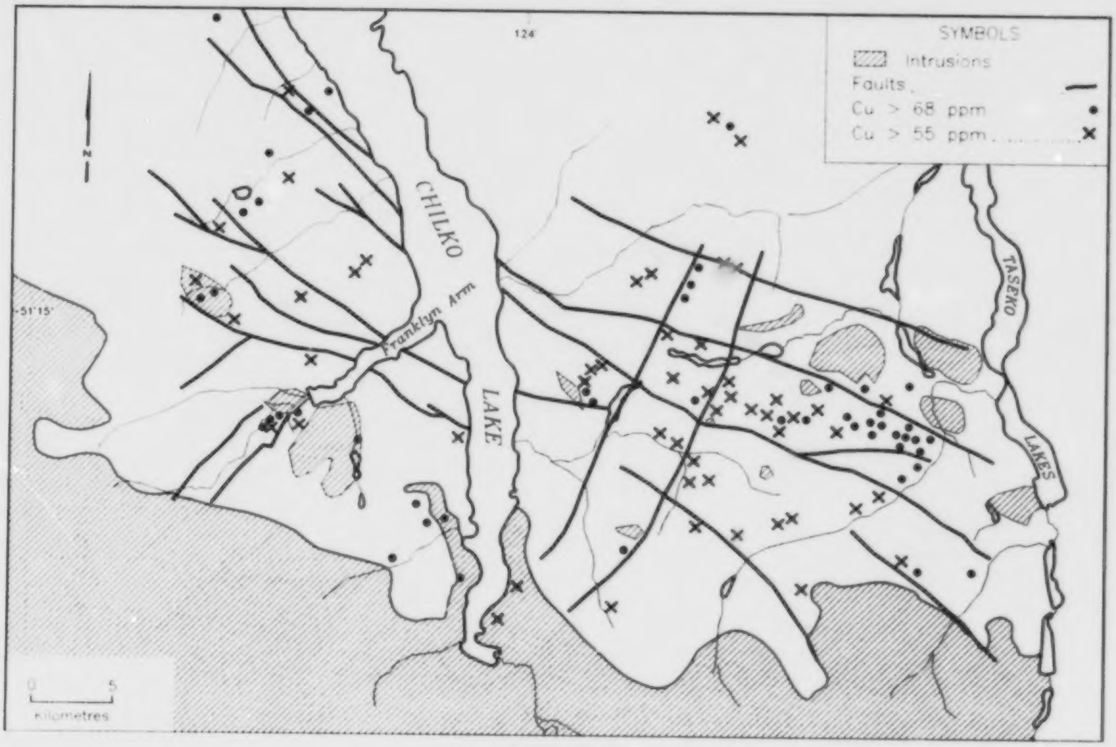
SYMBOLS
▨ Intrusions
Faults
Cu > 68 ppm ●
Cu > 55 ppm ×
124°
51°15'
N
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
0
5
Kilometres

Figure 17f.

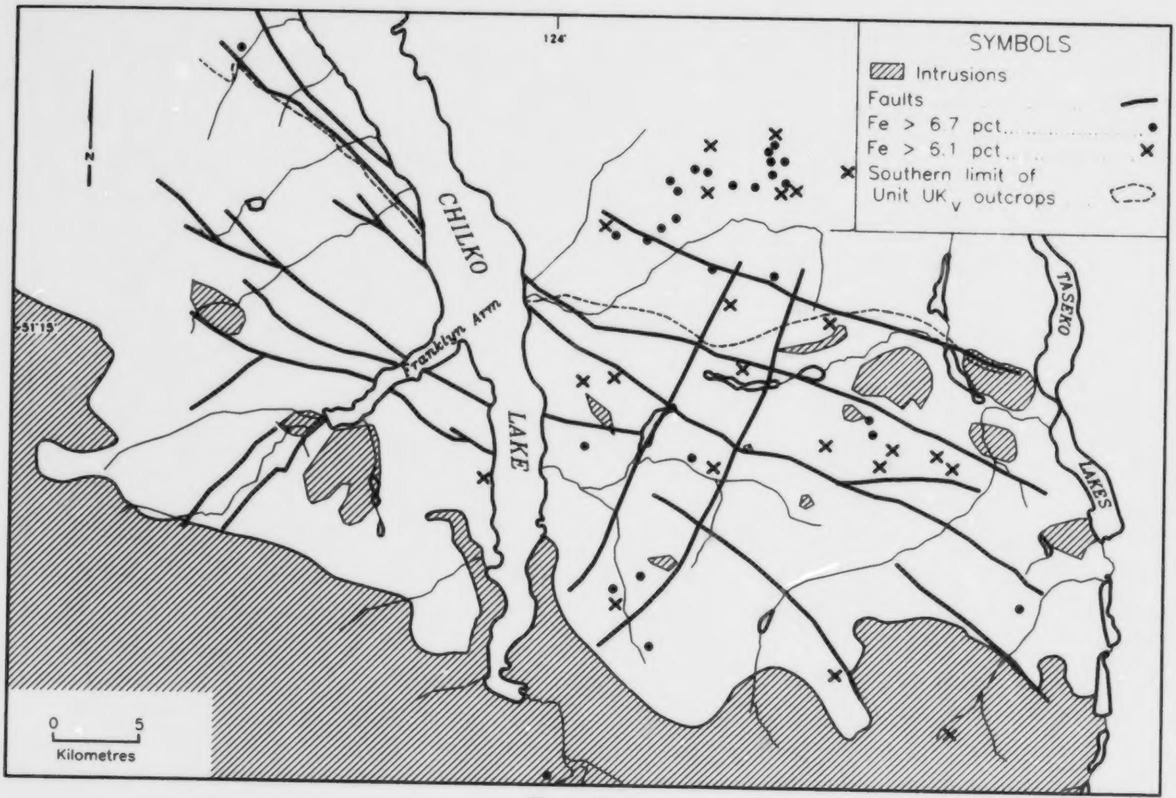
124°
SYMBOLS
▨ Intrusions
Faults
Fe > 6.7 pct
Fe > 6.1 pct
Southern limit of Unit UK$_v$ outcrops
N
CHILKO
LAKE
Franklyn Arm
51°15'
TASEKO
LAKES
0 5
Kilometres

Figure 17g.

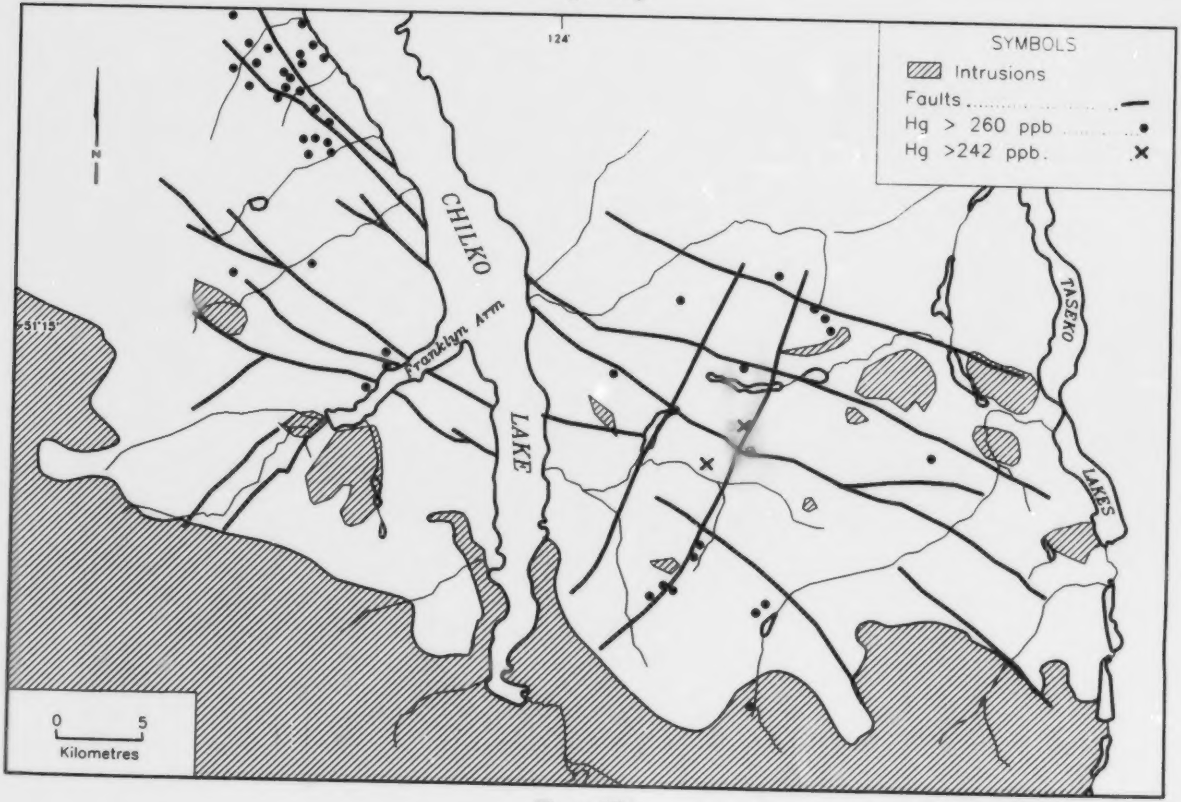
124°
SYMBOLS
▨ Intrusions
Faults
Hg > 260 ppb
Hg >242 ppb
N
CHILKO
LAKE
Franklyn Arm
51°15'
TASEKO
LAKES
0 5
Kilometres

Figure 17h.

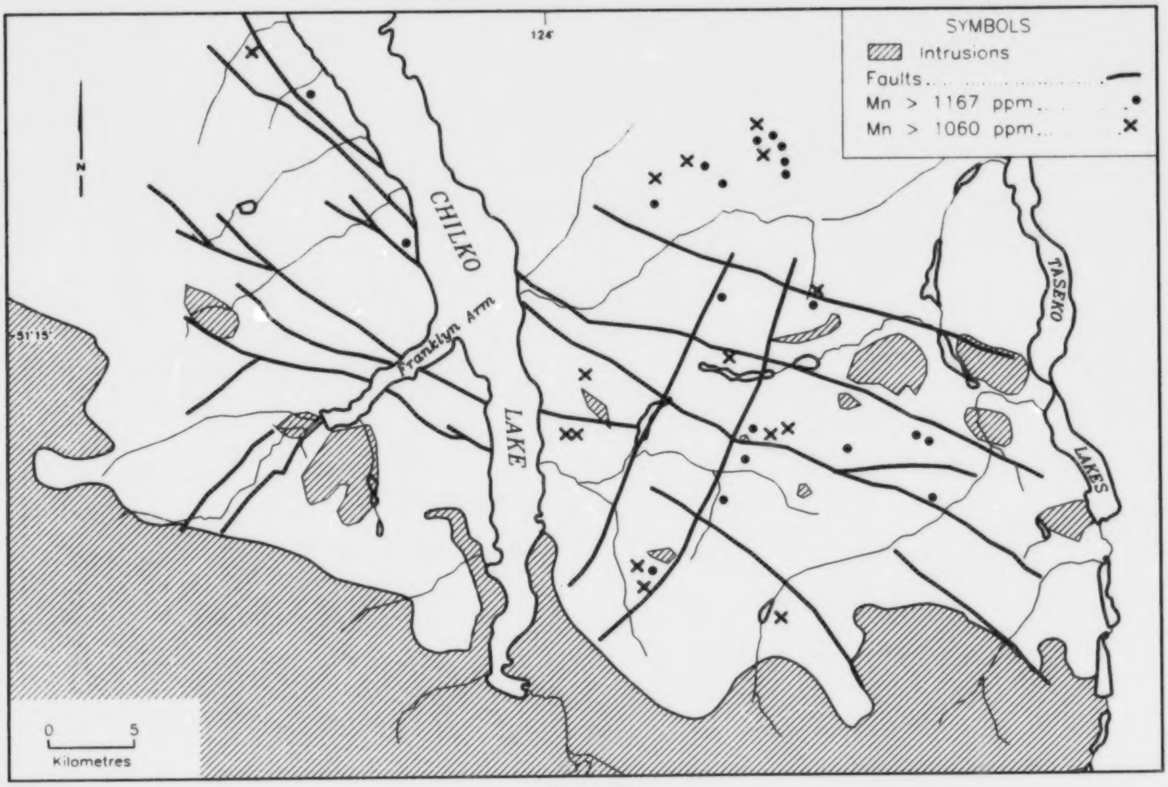
124°
SYMBOLS
▨ Intrusions
Faults
Mn > 1167 ppm ●
Mn > 1060 ppm ×
N
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
51°15'
0 5
Kilometres

Figure 17i.

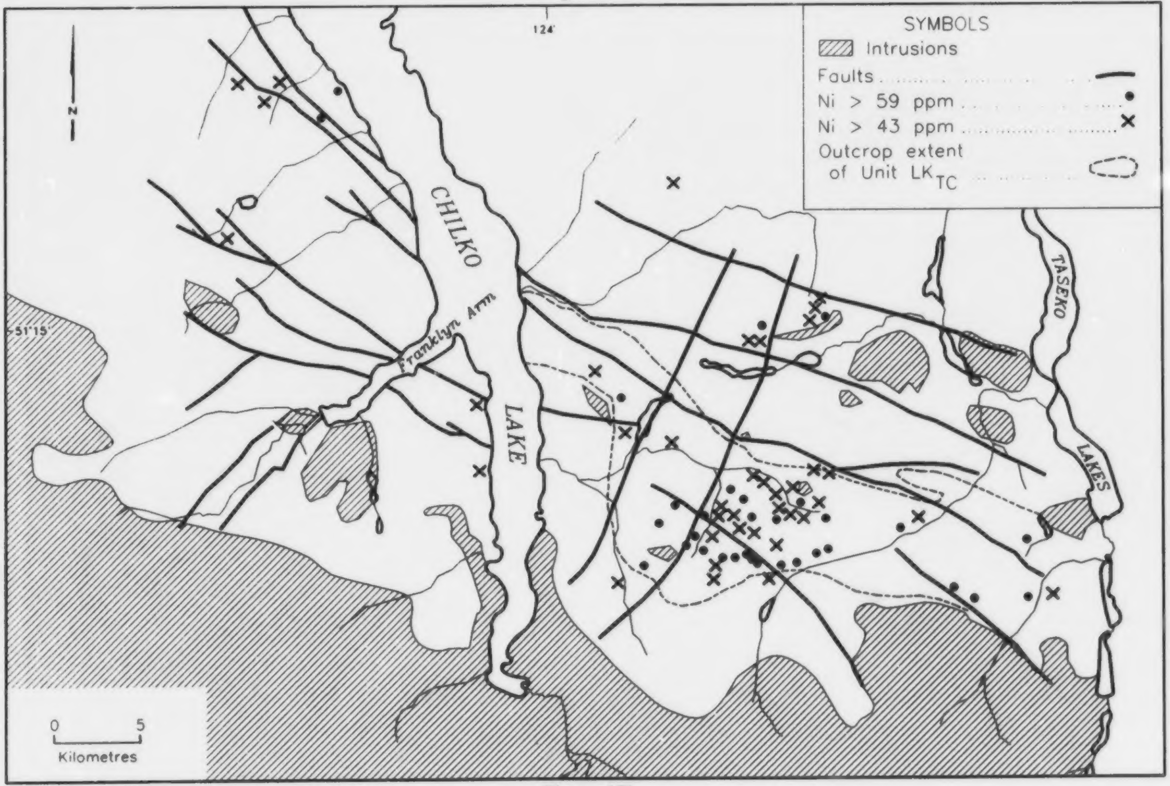
124°
SYMBOLS
▨ Intrusions
Faults
Ni > 59 ppm ●
Ni > 43 ppm ×
Outcrop extent of Unit LK_{TC}
N
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
51°15'
0 5
Kilometres

Figure 17j.

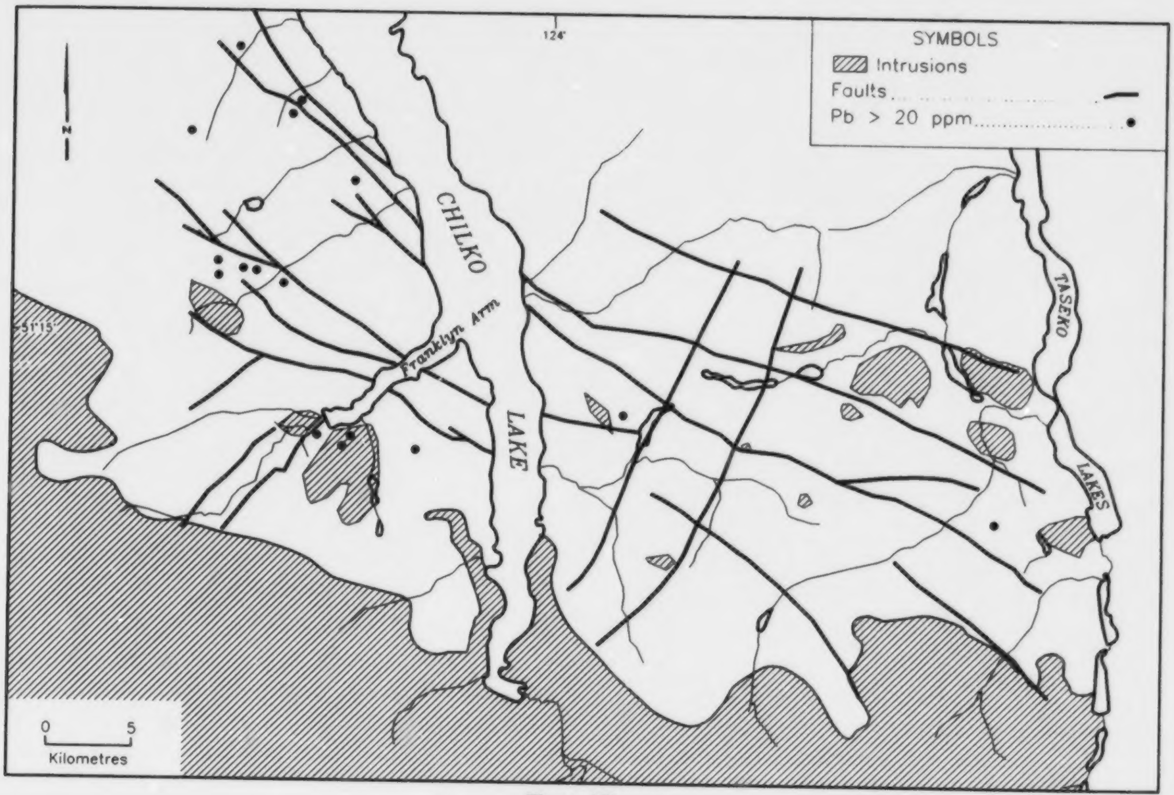
SYMBOLS
▨ Intrusions
Faults
Pb > 20 ppm
124°
N
51°15'
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
0 5
Kilometres

Figure 17k.

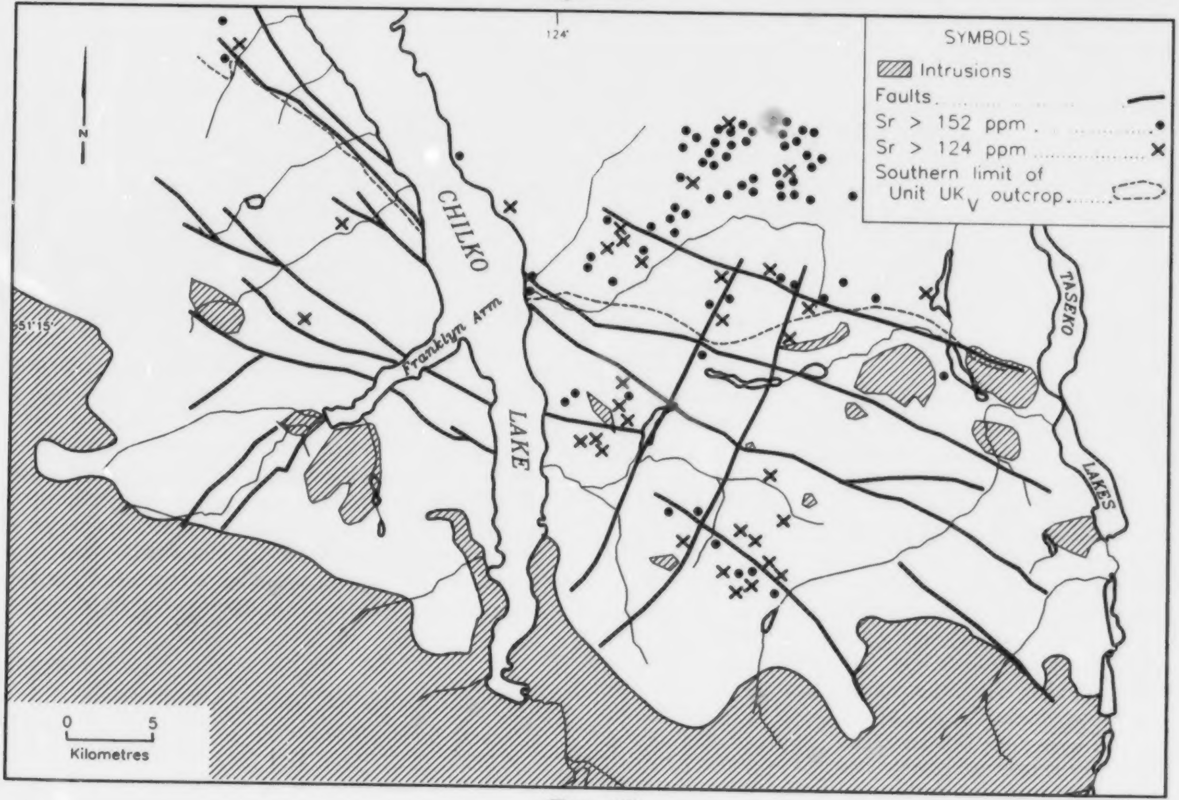
SYMBOLS
▨ Intrusions
Faults
Sr > 152 ppm ●
Sr > 124 ppm ×
Southern limit of Unit UK_V outcrop
124°
N
51°15'
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
0 5
Kilometres

Figure 17l.

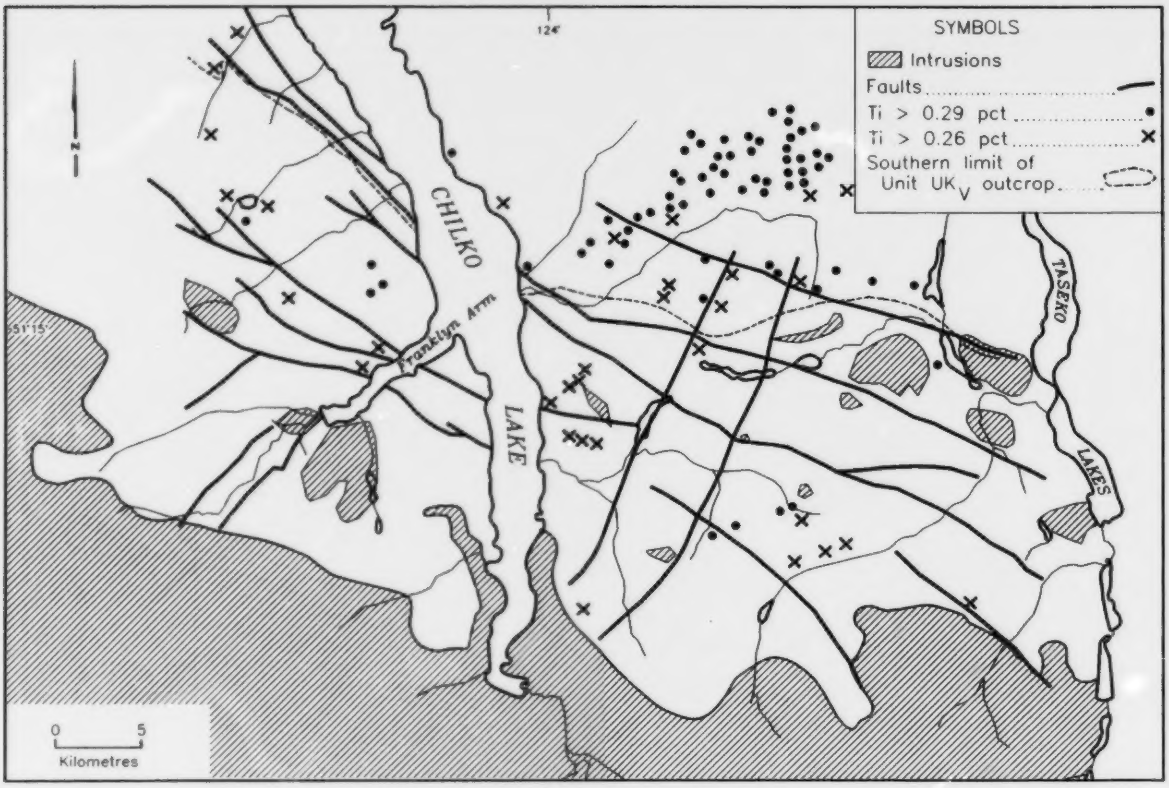
SYMBOLS
▨ Intrusions
Faults
Ti > 0.29 pct ●
Ti > 0.26 pct ×
Southern limit of Unit UK$_V$ outcrop
124°
51°15'
N
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
0 5
Kilometres

Figure 17m.

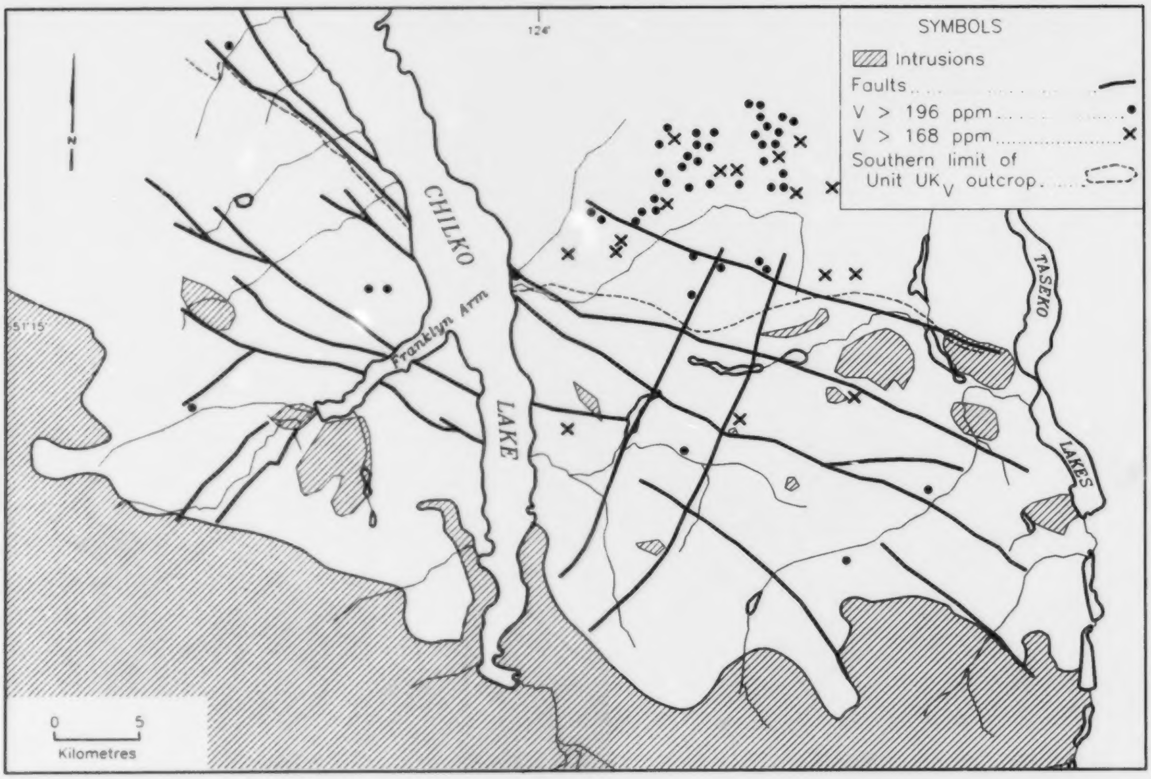
SYMBOLS
▨ Intrusions
Faults
V > 196 ppm ●
V > 168 ppm ×
Southern limit of Unit UK$_V$ outcrop
124°
51°15'
N
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
0 5
Kilometres

Figure 17n.

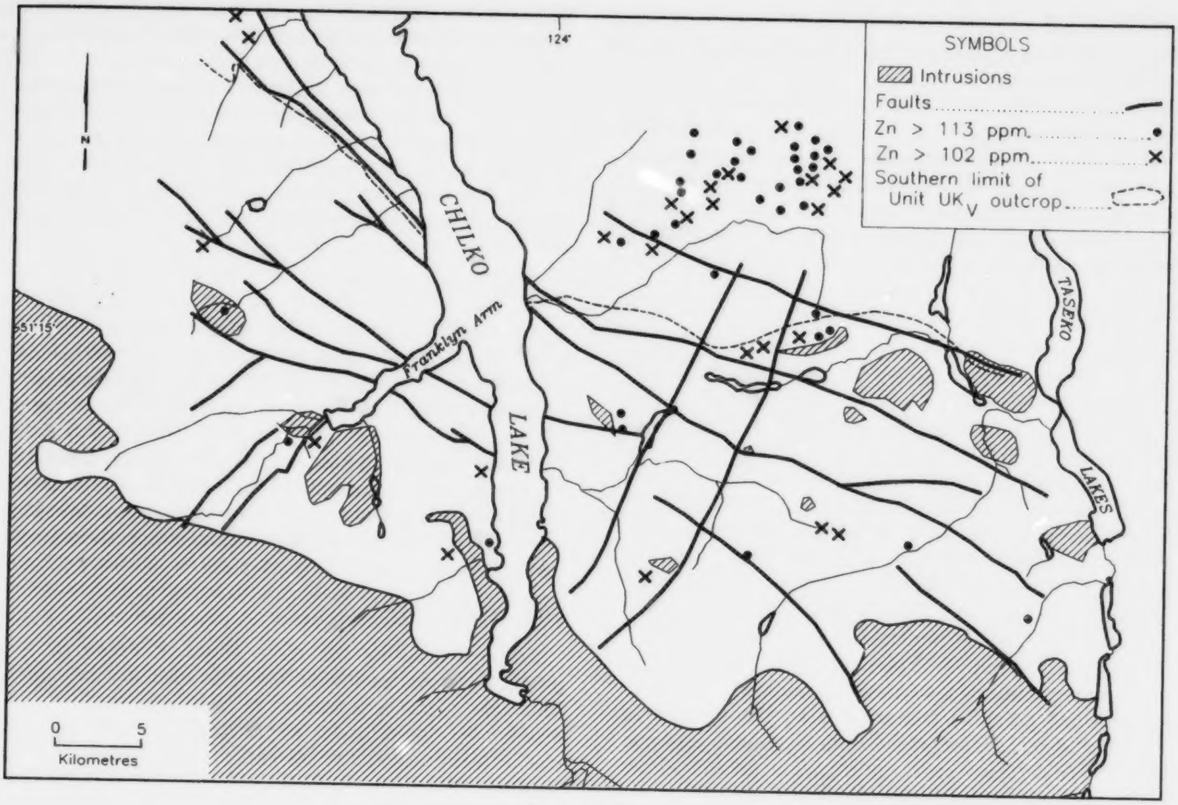

Figure 17o.

ALEXIS CREEK

Epithermal mercury-copper vein mineralization in the Tchaikazan fault near Alexis Creek is clearly defined by mercury anomalies in virtually all minor creeks draining the area. Barium anomalies show a strong clustering in these creeks and scattered high copper, lead, nickel and zinc values are also present. The zone of geochemical interest extends well beyond the limits of known mineralization, suggesting further prospecting along the Tchaikazan fault may prove rewarding. A previously unknown mercury-copper showing was discovered by prospecting the southern end of this zone in the course of fieldwork in this project. It is noteworthy that intrusive rocks are documented along the fault north of Girdwood Creek adjacent to the mineral showings and geochemical anomalies. The anomalous zone extends to the northern limit of sampling and may continue beyond the study area where a large intrusion with a gossanous aureole is clearly visible. The lack of geochemical responses south of Girdwood Creek may be due to the absence of intrusions in this area or to the poorer exposure at the lower elevations.

CHARLIE

A dense cluster of copper anomalies and two significant gold anomalies identifies a section of fractured volcanics hosting the known gold-quartz vein mineralization and porphyry copper mineralization at the southeast end of the Charlie zone. A distinct band of copper anomalies extends for more than 10 kilometres to the northwest, parallel to a fault containing localized copper-bearing gossans. This trend suggests potential for extending the Charlie zone mineralization. Intrusive rocks outcrop along this fault, further enhancing the potential for vein mineralization. Isolated anomalies in manganese, cobalt and arsenic are also present in this zone.

YOHETTA

The Yohetta zone, extending from Fishem Lake to the Yohetta valley, comprises an area of major faults and intrusive stocks that have developed large alteration zones in the surrounding rocks. This zone was identified in the Regional Geochemical Survey as containing numerous copper, zinc and iron anomalies. In this project three anomalous gold values were detected adjacent to the intrusions. North of the Yohetta valley a cluster of zinc anomalies (Figure 17o) together with isolated high values in mercury, barium and nickel, surround the intrusion and the large alteration zone associated with it. Copper and barium anomalies occur southwest of Fishem Lake adjacent to the Tchaikazan fault and an intrusion. Even though no significant mineralization is known in this zone, the favourable geological and geochemical indicators suggest potential for veins or stockworks containing base and precious metals.

TASEKO

The Taseko zone adjoins the Charlie zone to the southeast in an area of anomalous mercury, arsenic, zinc and lead values identified by the Regional Geochemical Survey. Stream sediments were not collected here during this project, however, large carbonate alteration zones in well-fractured volcanics were noted while prospecting. Faults and intrusions are similar to the Charlie and Yohetta zones. Previous work in this area noted minor copper mineralization with anomalous levels of lead and zinc.

TWIN CREEK

The Twin Creek zone covers a large segment of the contact of the Coast plutonic complex between the Falls and Tchaikazan valleys and includes the Pellaire gold occurrence. Isolated anomalies are present, some with relatively high values in gold, silver, arsenic, copper, zinc, lead and barium. Regional Geochemical Survey and industry exploration data also identified anomalous values in copper, lead, zinc, arsenic, silver and iron. Prospecting in this project, conducted partially as follow-up to all the stream sediment data, identified an arsenic-bearing breccia and copper mineralization with anomalous gold values in Twin Creek valley and copper-molybdenum mineralization in Discord valley. An anomalous gold value (135 ppb) is of particular interest as it was detected immediately below a prominent, limonitic, fault-controlled gorge in Discord Creek. The anomalous geochemical data, in combination with favourable geologic features and newly discovered mineralization, confirm a high potential for precious metal vein mineralization in this zone.

MOUNT GODDARD

The Mount Goddard zone is complexly faulted and cut by intrusive rocks. Known copper mineralization in the intrusion below Mount Goddard is clearly identified by a cluster of copper anomalies in stream sediments. Anomalous lead, zinc and arsenic values were also determined in this drainage. A high mercury anomaly (6100 ppb) and isolated barium and arsenic values, highlight a major fault in the northern part of the zone; this fault is an extension of the structure outlined in the Charlie zone. The potential for porphyry and vein mineralization is suggested.

TARN CREEK

A cluster of copper anomalies, and one of the few samples with detectable molybdenum, clearly identify an anomalous zone centred on Tarn Creek. A significant copper-bearing stockwork system in both volcanic and intrusive rocks was discovered here during this project. The valley is also the locus of a major northeast-trending fault; brecciation and carbonate alteration were noted around the valley. Isolated stream-sediment anomalies in iron, mercury, manganese and zinc were also detected in this zone. This environment offers potential for porphyry copper or possibly related vein or stockwork mineralization.

SPECTRUM PEAK

The zone south of Spectrum Peak comprises interbedded sedimentary and volcanic rocks cut by a stock of Coast plutonic rocks and a number of faults. Small clusters of mercury and barium anomalies were detected around the stock; isolated arsenic, copper, lead, zinc, manganese and iron anomalies were also identified. Prospecting in this area resulted in the discovery of copper-lead-zinc mineralization in talus but no source was found. Nickel, cobalt and strontium anomalies were determined in the eastern part of the zone; the nickel and cobalt appear to be representative of the underlying strata (*see* Stratigraphic Controls following) whereas the strontium anomalies tend to follow a fault cutting the zone.

DAISIE

A prominent cluster of copper anomalies, with two detectable molybdenum values, at the head of Franklyn Arm identifies the Daisie skarn mineralization. Isolated anomalies in arsenic, barium, lead and zinc were also detected. Stocks of the Coast plutonic rocks cut both Triassic and Lower Cretaceous strata in this area and provide a setting favourable for porphyry-style mineralization in addition to the known skarns. Previous geochemical surveys by industry have identified gold, tungsten and copper anomalies in stream sediments from this zone.

FRANKLYN ARM

Streams draining the north shore of Franklyn Arm provided isolated anomalies in arsenic, mercury and copper. This zone is cut by a number of faults and includes some distinct rhyolitic horizons within the volcanic stratigraphy; one of these contains minor copper mineralization. These features suggest a potential for vein or volcanogenic mineralization.

TREDCROFT CREEK

A stock of Coast plutonic rocks and the Stikelan fault both underlie drainages at the head of Tredcroft Creek. A number of copper and arsenic anomalies were detected adjacent to the stock while a cluster of lead anomalies appears to lie along the fault. Limonitic felsic volcanics were also noted adjacent to the lead anomalies. Isolated anomalous values in gold, mercury, barium and zinc were detected in this zone. This setting has potential for porphyry or vein mineralization. Copper anomalies in Girdwood Creek occur below epidote-quartz-altered fractures carrying native copper mineralization.

STRATIGRAPHIC CONTROLS

A correlation between the geographic distribution of anomalous values and the underlying stratigraphy is noted for certain groups of elements in two areas. Anomalous nickel and cobalt values tend to fall within the outcrop patterns of Unit LK_{TC} through the centre of the map area while anomalous levels of strontium, titanium, vanadium and zinc are concentrated within Unit UK_v across the northern portion of the area.

Nickel data partition into three populations; 90 per cent of the samples in the upper population were collected in basins underlain by Unit LK_{TC} (Figure 17j). A second population with considerable overlap on the first (Figure 15j) is also derived largely from this unit but includes a wider dispersion from other areas. Cobalt, which partitions into a bimodal distribution, also displays a strong correlation between samples in the anomalous population and Unit LK$_{TC}$ lithologies (Figure 17d). The reason for this close association of elevated nickel and cobalt with Unit LK$_{TC}$ rocks is not clear. Johnson (1984) has noted that mean nickel values from the Regional Geochemical Survey conducted in map 92O are significantly higher in sedimentary rocks (84.8 ppm) than in volcanic rocks (34.5 ppm). Unit LK$_{TC}$ contains an appreciable volume of interbedded sedimentary rocks that may be responsible for the elevated concentrations. Probability plot analysis of the nickel and cobalt data has highlighted the distinctive geochemical character of Unit LK$_{TC}$, possibly reflecting a unique provenance for the sedimentary lithologies of the unit. Speculatively, this provenance may be an uplifted equivalent to the ultramafic rocks of the Bridge River Terrane.

Strontium, titanium, vanadium and zinc all have bimodal distributions with between 10 and 22 per cent of the data falling into an upper population. Geographic distribution of values above the upper threshold levels, that is solely from the upper population, shows a strong association with drainage basins underlain by volcanic rocks of Unit UK$_{V}$ (Figures 17l, m, n, and o). Anomalous iron and chromium values also show a distinct clustering with these rocks (Figures 17g and e). Again the reasons for this multi-element grouping occurring within this particular volcanic succession are not understood, however, it is clear that this geochemical signature must reflect the geologic processes controlling its deposition.

The association of anomalous metal levels in stream silt with intrusions or with faults indicates zones of greater mineral potential and provides guidelines for further exploration of the region. These features are traditional exploration targets, however, the geochemical data provide a sharper focus on zones of particular interest and a guide to the suite of elements that should be determined in further prospecting. The stream-sediment survey data have also provided information on the geochemical signatures of certain rock units and therefore serve as a useful aid in interpreting the geology.

A correlation matrix for the elements discussed above (Appendix A, Table A-4) illustrates that many of the most significant correlations occur amongst the strontium-titanium-vanadium-zinc-iron-chromium group, that is amongst those elements found clustering in Unit UK$_{V}$, and between nickel and cobalt, the elements found in Unit LK$_{TC}$. Furthermore, the mercury-barium-nickel association found near Alexis Creek is confirmed by significant correlations. However this matrix also shows a number of correlations of little importance in terms of distribution of anomalous data.

LITHOGEOCHEMISTRY

Prospecting and rock-chip sampling, conducted in the course of geologic mapping, were aimed at providing a more direct characterization of known mineralization and of environments considered to have potential for mineralization. These environments include gossan zones, silica or carbonate alteration zones, areas of quartz or carbonate veining and fault zones. A total of 368 rock-chip samples were collected and analyzed for 15 elements, including precious metals, precious metal indicators and base metals. A complete list of analytical data is provided in Appendix B and has been previously published with sample location maps (McLaren, 1987b, c). Appendix B also describes the analytical methods used; Figure 18 shows the distribution of sample locations.

Lithogeochemical data were coded according to two criteria, mode of occurrence and host rock unit. Eight modes of occurrence were tabulated in three broad categories of inferred geologic control. Structurally controlled modes include veins, carbonate alteration zones, silica alteration zones and fault zones. A clear distinction is not always possible between these modes as they may all occur together on a large scale. The mode representing the most dominant feature of the material sampled was used. Veins may be related to a complex interplay of structural and intrusive activity, however, all vein occurrences have been tabulated in the structural category, including those related to intrusive contacts. Modes attributed to intrusive control include hornfels zones, skarns, and stockwork/porphyry zones. Finally, those samples taken from areas where the geologic control is unknown were simply described as gossans. These include volcanic and sedimentary rocks with sulphide mineralization that is possibly of syngenetic origin. The number of samples attributed to each mode is shown in Table 6. The analytical data are tabulated according to mode of occurrence in Appendix B.

TABLE 6
DISTRIBUTION OF LITHOGEOCHEMICAL SAMPLES BY MODE OF OCCURRENCE

Mode:	Number of Samples	Mode:	Number of Samples	Mode:	Number of Samples
Structural Controls		**Intrusive Controls**		**Unknown Controls**	
Veins	82	Hornfels	63	Gossans	61
Carbonate alteration	21	Skarns	5		
Silica alteration	21	Stockwork/ Porphyry	31		
Faults	84	**Total**	**99**		
Total	**208**				

Statistical manipulation of these data to provide the regional character of each mode has not proved to be meaningful due to the highly biased nature of sampling. Samples were taken specifically from zones of higher potential and areas of strong mineralization were sampled more extensively than others. As a result, mean values for any particular mode have been strongly influenced by a handful of samples from a specific location and the standard deviation is often many times greater than the mean value. However, in comparing the data it is evident that vein samples contain many of the highest values in the precious metals and precious metal indicator elements (mercury, arsenic, antimony, bismuth) plus copper, lead and zinc. Mercury is anomalously high in all the structurally controlled environments. Copper and molybdenum tend to be high in the skarn and stockwork/porphyry environments, but the number of samples taken from these environments was small.

The lithogeochemical data are of greatest importance as a prospecting guide to zones of anomalous metal values in

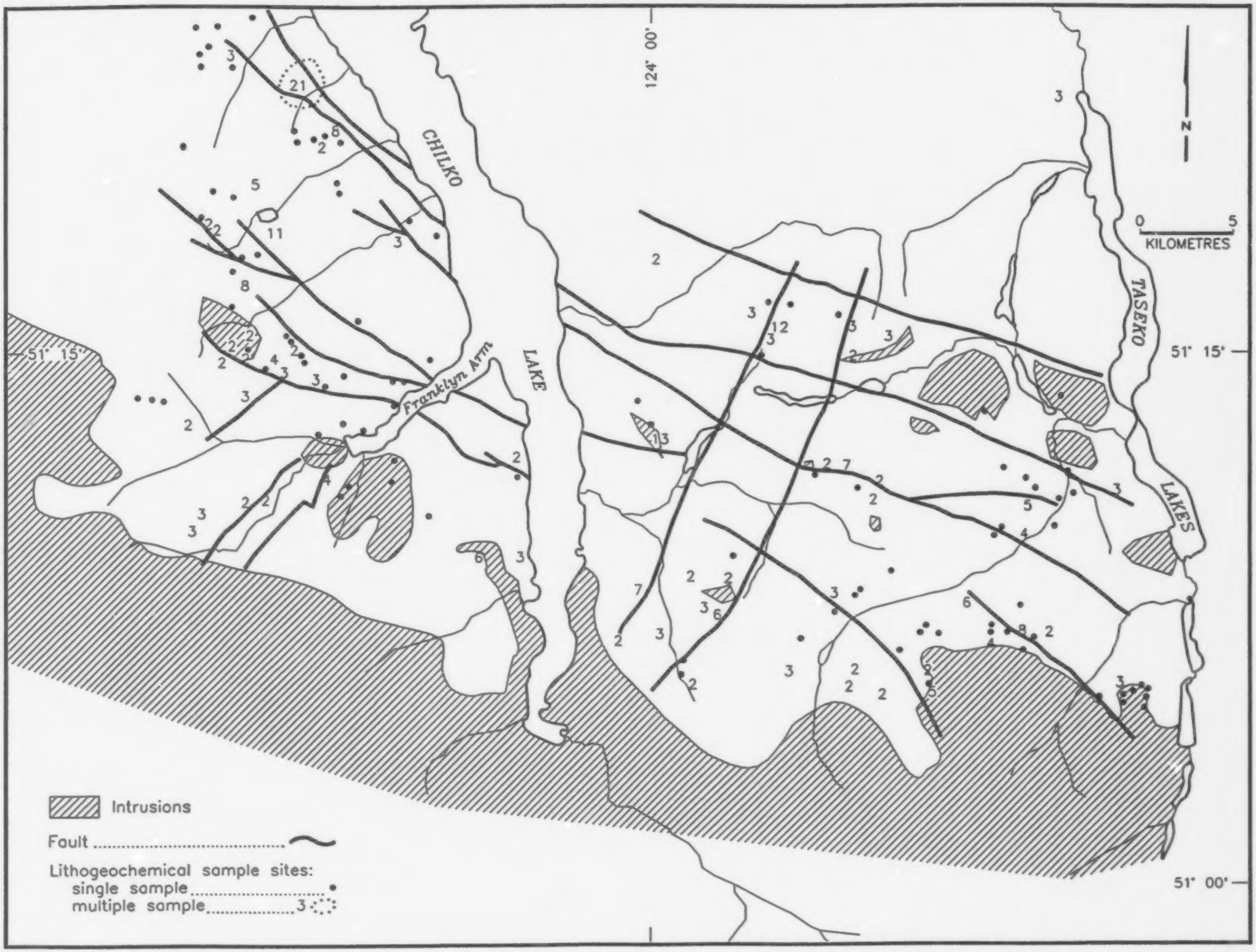
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
124° 00'
51° 15'
51° 00'
N
0
5
KILOMETRES
Intrusions
Fault
Lithogeochemical sample sites:
single sample
multiple sample
3
21

Figure 18. Distribution of lithogeochemical sample sites.

areas of favourable geology as well as in attempting to characterize the metals present in known mineral occurrences so that a metallogenic model can be applied. A more detailed discussion of the lithogeochemistry of mineralized zones, and its metallogenic significance, is given in Chapter 4. This discussion takes a broader approach in correlating areas of anomalous lithogeochemical data with mode of occurrence and geologic features across the study area as a whole. Threshold values clearly segregating anomalous and background concentration levels cannot be calculated due to the sampling bias. 'Approximate threshold' values, shown in Table 7, were estimated by visually scanning the data to determine anomalous results based on both relative and absolute values. Even though these thresholds are chosen somewhat arbitrarily, they identify the lithogeochemical data that provide a focus on worthwhile prospecting targets and zones of higher mineral potential.

TABLE 7
"APPROXIMATE THRESHOLD VALUES"
FOR LITHOGEOCHEMICAL DATA

Element	Threshold	Element	Threshold
Au	300 ppb	Cu	500 ppm
Ag	7.0 ppm	Pb	120 ppm
Hg	800 ppb	Zn	400 ppm
As	100 ppm	Fe	10 %
Sb	100 ppm	Mo	100 ppm
		Mn	2200 ppm

The lithogeochemical data, viewed in conjunction with the regional geology, suggest three major metallogenic environments are present in the Chilko Lake Planning Area. These are: (1) a structurally controlled environment, (2) an intrusion-related environment, and (3) a volcanogenic massive sulphide environment. Figure 19 illustrates the distribution of these environments as outined by the lithogeochemical data. These zones are smaller than the zones of higher mineral potential identified by the stream sediment data but frequently overlap them. Again no attempt is made to rank the zones shown in Figure 19. The characteristics of each metallogenic environment are summarized in Table 8 and are briefly discussed in the following paragraphs.

TABLE 8
CHARACTERISTICS OF METALLOGENIC ENVIRONMENTS
AS DEFINED BY LITHOGEOCHEMICAL DATA

Metallogenic Environment	Geochemical Signature	Geological Features	Environment of Formation
Structural	Hg As Sb Ag Au Cu Pb Zn Fe	extensive fault-zones; carbonate or silica alteration zones; quartz and carbonate veining	hydrothermal mineralization imposed on host-rocks
Intrusive	Cu Mo Au Ag Hg As Pb Zn Mn Fe W, Ta	granitic intrusions; disseminated porphyry-style mineralization; quartz veining and stockwork zones; skarn development in limestones	hydrothermal mineralization imposed on host-rocks
Volcanogenic Massive Sulphide	Ag Cu Pb Zn Fe	gossanous lenses or horizons, generally in felsic volcanics; pyrite, pyrrhotite, minor chalcopyrite	syngenetic mineralization in a volcanic island arc and basin environment

The distribution of anomalous samples from structurally controlled environments is illustrated in Figure 20. In most cases multiple samples have been taken and anomalous values in different elements may be present in different samples. It is clear that the major fault zones contain veins mineralized with a characteristic suite of elements. Mercury, arsenic and antimony together with silver and gold are the most common constituents; copper, lead, zinc and iron may be present. The alteration zones and the rocks within fault zones that are not conspicuously veined contain fewer distinctive elements, but typically include mercury and arsenic. The Tchaikazan fault zone is clearly anomalous west of Chilko Lake as is the portion of the Stikelan fault at the head of Girdwood Creek on the western border of the study area. Similar isolated anomalies occur elsewhere along these fault zones. Intrusive rocks are the probable source of mineralizing solutions circulating in the fault zones; granitic stocks and dikes crudely align with the faults and are often associated with the strongest mineralization. Furthermore, two of the three vein occurrences between the Lord and Tchaikazan rivers occur on the contact of the Coast plutonic complex where the influence of intrusive activity may be extensive. The three known gold-bearing vein occurrences (Pellaire, Charlie group, and Vick) all returned highly anomalous contents of precious metals and precious metal indicator elements.

Figure 21 shows the distribution of anomalous samples from environments with intrusive controls. The stockwork/porphyry environment almost always contains high copper values with or without anomalous levels of molybdenum, gold and silver; a variety of other metals including mercury, arsenic, lead, zinc, iron and manganese may or may not be present. The porphyry occurrence in the lower Tchaikazan valley contains distinctly anomalous levels of copper and molybdenum. The large number of hornfels zones sampled provided few anomalous samples; where anomalies exist they contain elements characteristic of other nearby mineralization. Four of the five skarn samples collected come from the Daisie mineralization at the head of Franklyn Arm; they returned strongly anomalous levels of silver, copper, zinc and iron. High levels of molybdenum, cobalt, nickel, tungsten and tantalum are also present. Due to this limited sampling, little more can be said about the skarn mineralization, however it is significant that these elements confirm the lithogeochemical signature found in other occurrences with intrusive controls. Figure 21 also displays anomalous elements from gossan samples of uncertain control. These samples tend to be anomalous in silver and a variety of base metals (copper, lead, zinc, iron).

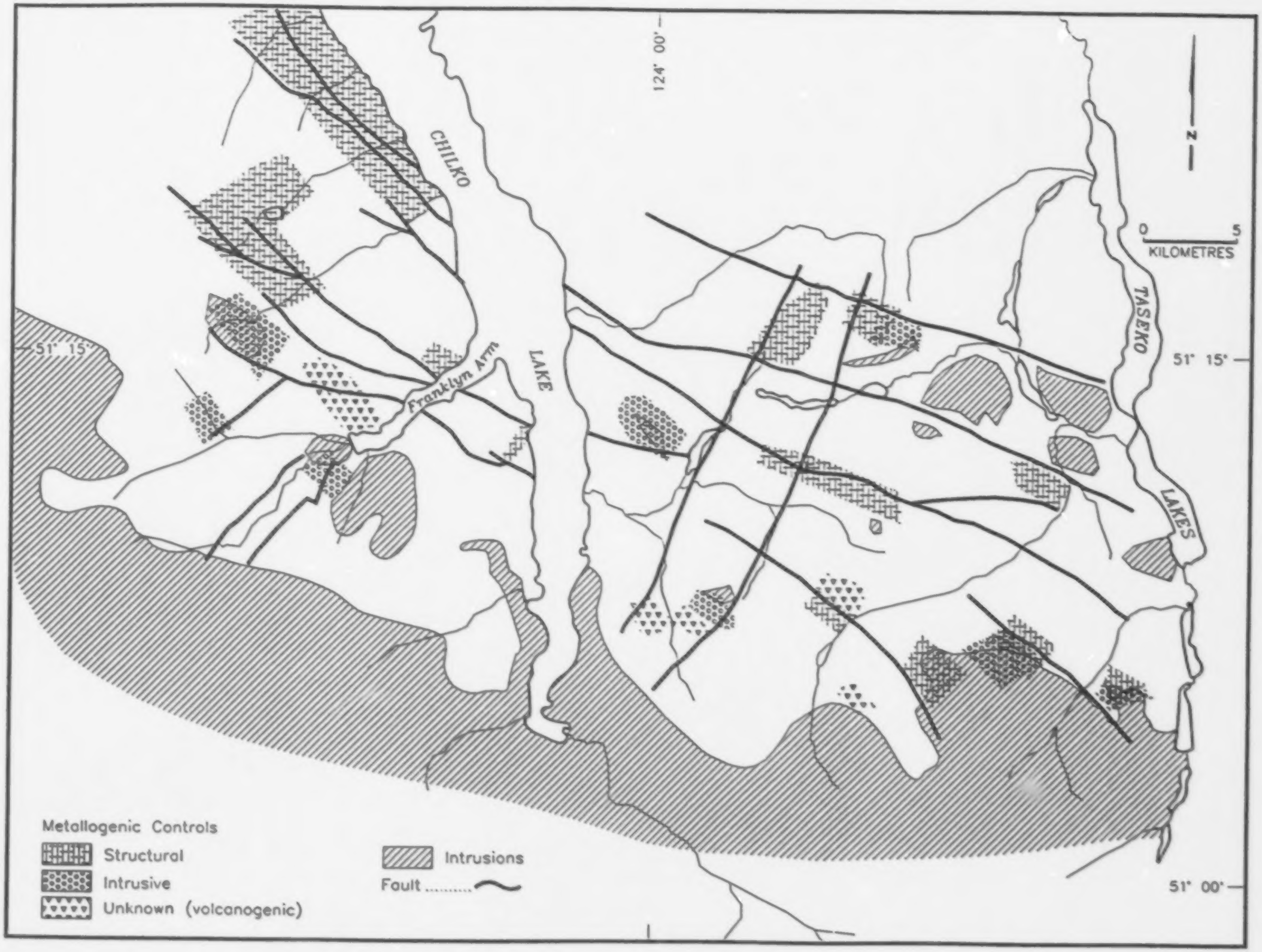
N
0 5
KILOMETRES
124° 00'
51° 15'
51° 15'
51° 00'
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
Metallogenic Controls
Structural
Intrusive
Unknown (volcanogenic)
Intrusions
Fault

Figure 19. Distribution of zones of greater mineral potential as defined by lithogeochemical data.

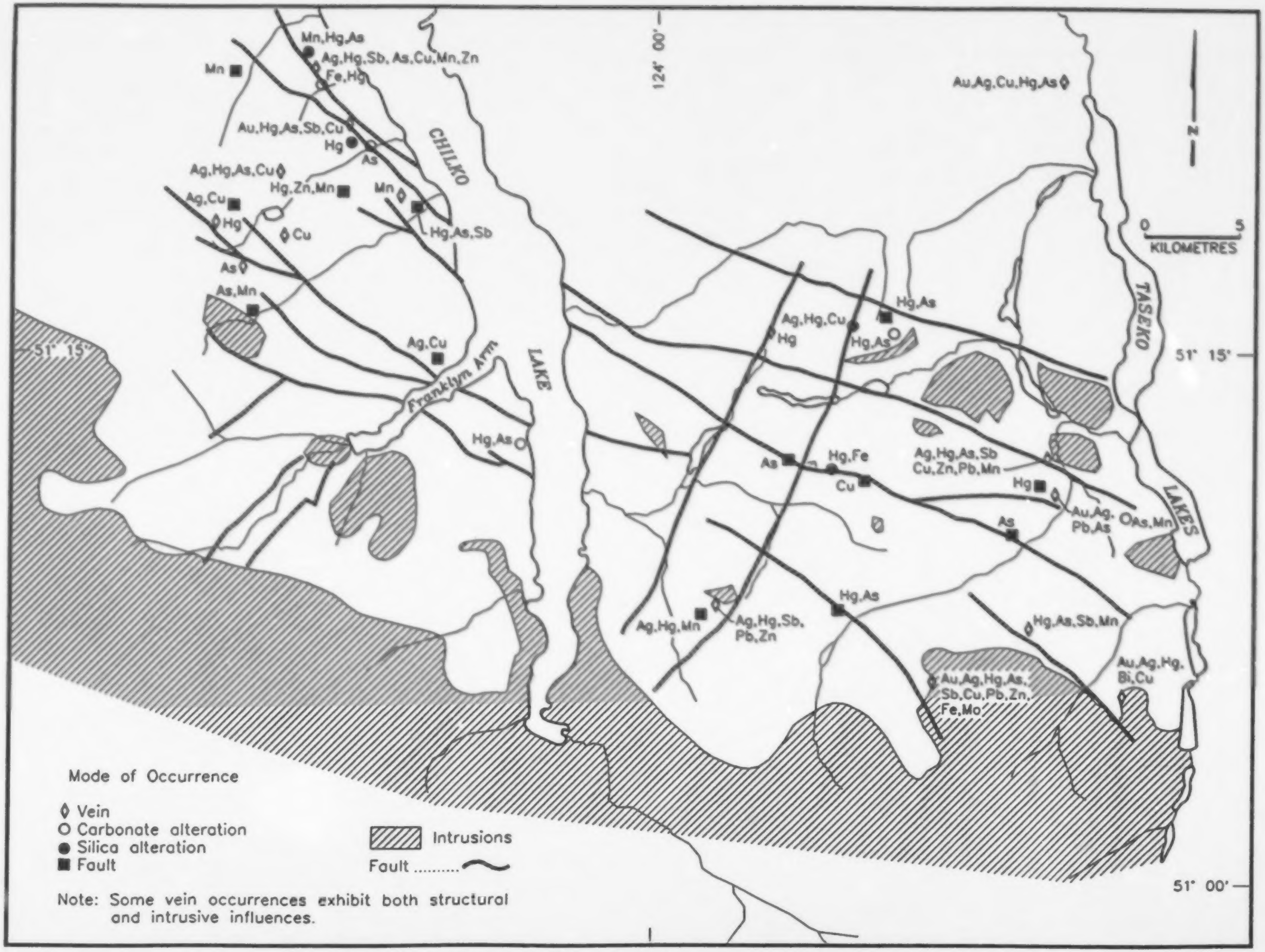
124° 00'
Mn,Hg,As
Ag,Hg,Sb,As,Cu,Mn,Zn
Fe,Hg
Mn
Au,Hg,As,Sb,Cu
Hg
As
CHILKO
Ag,Hg,As,Cu
Hg,Zn,Mn
Mn
Ag,Cu
Hg
Cu
Hg,As,Sb
As
As,Mn
51° 15'
Ag,Cu
Franklyn Arm
LAKE
Hg,As
Au,Ag,Cu,Hg,As
N
0
5
KILOMETRES
TASEKO
LAKES
51° 15'
Hg,As
Ag,Hg,Cu
Hg
Hg,As
Ag,Hg,As,Sb
Cu,Zn,Pb,Mn
As
Hg,Fe
Cu
Hg
Au,Ag,
Pb,As
As,Mn
As
Hg,As
Ag,Hg,Mn
Ag,Hg,Sb,
Pb,Zn
Hg,As,Sb,Mn
Au,Ag,Hg,
Bi,Cu
Au,Ag,Hg,As,
Sb,Cu,Pb,Zn,
Fe,Mo
51° 00'
Mode of Occurrence
◊ Vein
○ Carbonate alteration
● Silica alteration
■ Fault
▨ Intrusions
Fault ....
Note: Some vein occurrences exhibit both structural and intrusive influences.

Figure 20. Distribution of anomalous lithogeochemical samples in environments exhibiting structural controls.

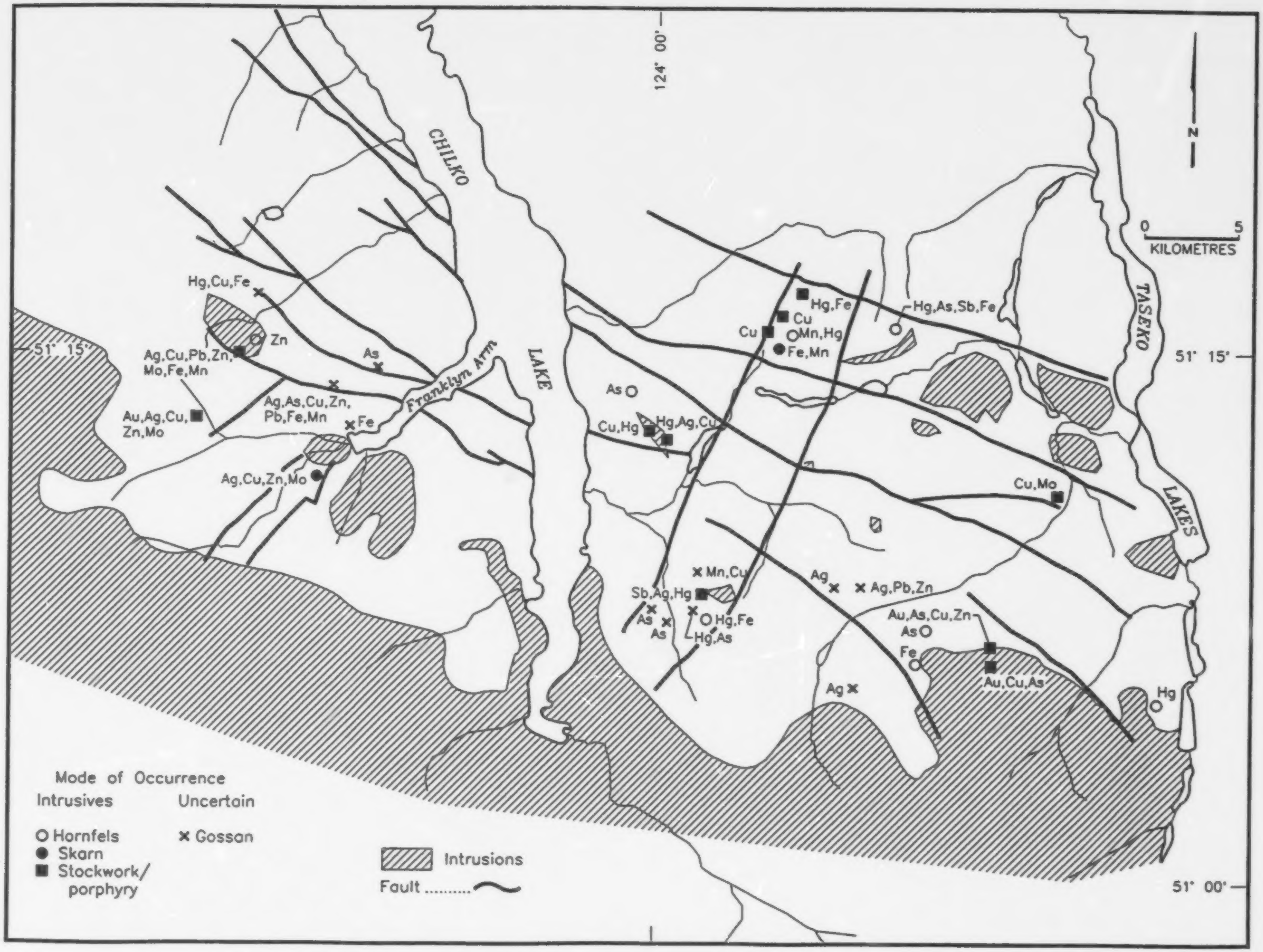
124° 00'
N
0 5
KILOMETRES
CHILKO
LAKE
Franklyn Arm
TASEKO
LAKES
51° 15'
51° 15'
51° 00'
Hg,Cu,Fe
Zn
Ag,Cu,Pb,Zn,
Mo,Fe,Mn
As
Au,Ag,Cu,
Zn,Mo
Ag,As,Cu,Zn,
Pb,Fe,Mn
Fe
Ag,Cu,Zn,Mo
As
Cu,Hg
Hg,Ag,Cu
Hg,Fe
Cu
Cu
Mn,Hg
Fe,Mn
Hg,As,Sb,Fe
Cu,Mo
Mn,Cu
Sb,Ag,Hg
As
As
Hg,Fe
Hg,As
Ag
Ag,Pb,Zn
Au,As,Cu,Zn
As
Fe
Au,Cu,As
Ag
Hg
Mode of Occurrence
Intrusives
Uncertain
○ Hornfels
● Skarn
■ Stockwork/ porphyry
× Gossan
▨ Intrusions
Fault

Figure 21. Distribution of anomalous lithogeochemical samples in environments exhibiting intrusive or uncertain controls.

Figures 20 and 21 illustrate that lithogeochemical parameters can be used to distinguish the three modes of occurrence. Different suites of elements characterize the structural, intrusive and uncertain geologic environments. This is best shown west of Chilko Lake where anomalous samples in the Tchaikazan and Stikelan fault zones are clearly separated, both spatially and by geochemical signature, from anomalous samples collected from the zone of intrusive stocks lying subparallel to the contact of the Coast Complex. As noted in Chapter 2, this distribution of intrusive rocks and the extensive zones of hornfels suggests that the area is underlain by granitic rocks related to the Coast plutonic complex. If so, the metallogenic environment of the intrusive belt would be quite different from that dominated by the northwest-trending fault zones cutting the volcanic and sedimentary sequences immediately to the northeast. The lithogeochemical data support this premise. East of Chilko Lake a number of isolated stocks cut the faulted volcanic and sedimentary succession, hence the metallogenic environments and the resulting geochemical signatures overlap, as seen southwest of Spectrum Peak, north of the Yohetta valley and in the area between the Tchaikazan and Lord rivers. Sampled areas of uncertain metallogenic control were often simply limonitic or pyritic (± pyrrhotite) lenses or layers in volcanic or sedimentary rocks. Anomalous samples in this category are enriched in elements typical of stratabound massive sulphide deposits (copper, lead, zinc, iron, silver), supporting the suggestion that some of these zones may be syngenetic in origin. Correlations of Lower Cretaceous stratigraphy in southwestern British Columbia proposed in Chapter 2 also highlight the potential for volcanogenic copper-zinc-silver mineralization in these rocks. The depositional environment of these occurrences is related to specific stratigraphic horizons and therefore overlaps both the intrusive and structural environments, as shown in Figure 21.

Lithogeochemical data from assessment reports have not been included in the above discussion as each report contains different data sets which may not be directly comparable with each other or with the suite of elements analysed in this study. The assessment report data, which serve to enlarge the known areas of lithogeochemical anomalies, are discussed in Chapter 4.

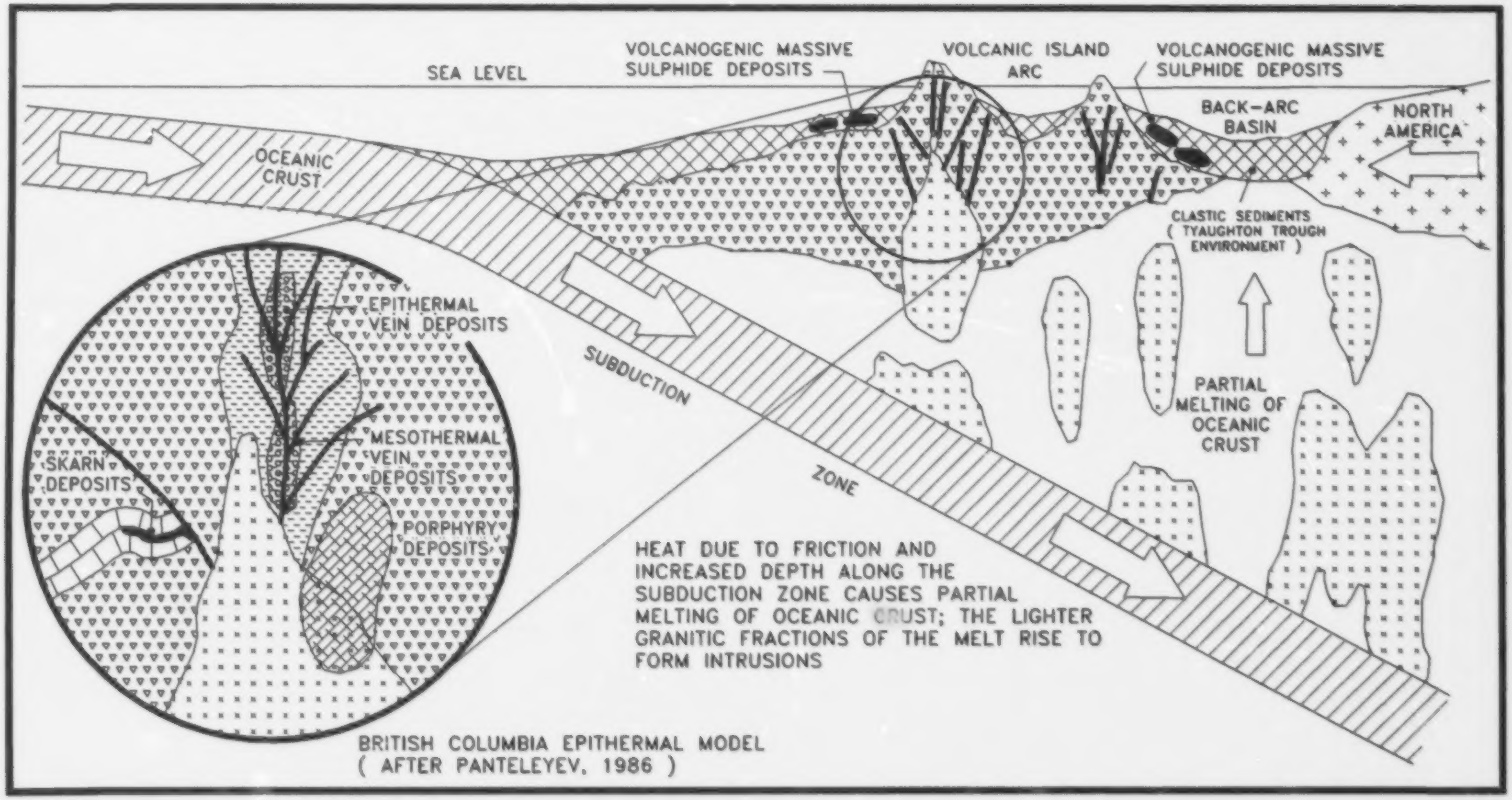
SEA LEVEL
VOLCANOGENIC MASSIVE SULPHIDE DEPOSITS
VOLCANIC ISLAND ARC
VOLCANOGENIC MASSIVE SULPHIDE DEPOSITS
BACK-ARC BASIN
NORTH AMERICA
OCEANIC CRUST
CLASTIC SEDIMENTS (TYAUGHTON TROUGH ENVIRONMENT)
EPITHERMAL VEIN DEPOSITS
SUBDUCTION
PARTIAL MELTING OF OCEANIC CRUST
MESOTHERMAL VEIN DEPOSITS
SKARN DEPOSITS
ZONE
PORPHYRY DEPOSITS
HEAT DUE TO FRICTION AND INCREASED DEPTH ALONG THE SUBDUCTION ZONE CAUSES PARTIAL MELTING OF OCEANIC CRUST; THE LIGHTER GRANITIC FRACTIONS OF THE MELT RISE TO FORM INTRUSIONS
BRITISH COLUMBIA EPITHERMAL MODEL (AFTER PANTELEYEV, 1986)

Figure 22. Conceptual models of mineral deposit genesis at convergent plate margins.

CHAPTER 4

MINERALIZATION

INTRODUCTION

Metallogeny is the study of the genesis of mineral deposits with emphasis on their relationships, in space and time, to regional geologic and tectonic features of the earth's crust.* Mineral resource assessments employ metallogenic thought at two stages: first, in the initial phase of the assessment to predict deposit types expected and therefore to design surveys to detect them; and second, late in the assessment, when all geological, geochemical and geophysical data are synthesized and matched to metallogenic models, to provide a qualitative measure of mineral potential. Metallogenic models provide a conceptual, idealized representation of a particular deposit type that embodies all known critical and diagnostic criteria for that deposit type (Sangster, 1986). As most mineral resource assessments cannot be expected to provide definitive, quantitative data on the geology and mineral resources of a region, metallogenic models provide a framework for predicting mineral potential which can be supported by qualitative and semiquantitative data gathered in the field. Potential for the existence of a given type of mineral deposit increases as more of the model's diagnostic criteria are satisfied.

Metallogenic models have both a descriptive and a genetic component. Existing generic models have been derived from the compilation of many years of research on similar deposits around the world. These have then been adapted into more specific models to fit specific areas, as local variations become known. Metallogenic models pertinent to British Columbia have evolved in conjunction with modern concepts of the origin of the tectonic terranes that comprise the Canadian Cordillera. The genetic basis for these models is closely linked to the plate tectonic processes that produced the terrane assemblage, hence metallogenic studies must consider the plate tectonic framework of the area being studied.

As outlined in Chapter 2, the varied geology of the Chilko Lake Planning Area records a collision between a composite allochthonous terrane, arriving from the west, and the coast of North America. In the larger plate tectonic framework, this area represents a small segment of a convergent plate margin, that is, a zone where two of the earth's major tectonic plates collide. Convergence during the Cretaceous resulted in the North American continental rocks overriding the oceanic crust from the Pacific; the oceanic material was subducted beneath the continent (Figure 22). Subduction boundaries along convergent plate margins create volcanic island arcs and basins along belts of increased igneous activity; well defined belts of volcanic and plutonic rocks, such as seen in western British Columbia, result from this process. Major displacements along extensive fault zones are also an important feature of convergent boundaries as collisions often occur at an oblique angle. Many of the features characteristic of a subductive convergent plate margin have been identified in the Chilko Lake Planning Area.

McMillan *et al.* (1987) have discussed the nature of mineral deposits commonly found in convergent plate margin settings in British Columbia. These include epithermal and mesothermal vein deposits, porphyry and skarn deposits, and volcanogenic massive sulphide deposits (Figure 22). The geological and geochemical surveys carried out in this project have shown that metallogenic processes able to produce these types of deposits have been active in the Chilko Lake Planning Area. Metallogenic models can be applied to the area to develop a qualitative analysis of the mineral potential. Realistic exploration targets can be identified using these models. Comparisons with adjacent 'training tracts' of analogous geology and proven mineralization that have an extensive exploration history strongly enhance the applicability of metallogenic models in support of the geochemical and geological indicators.

Mesothermal and epithermal veins are the most common type of known mineral occurrence in the Chilko Lake Planning Area and appear to have the greatest potential for future production. The Pellaire property contains numerous gold and silver-bearing quartz veins that have been intermittently explored by surface drilling and underground openings since the 1930s. Exploration of this property was revived in 1987 and 1988; initial results from surface drilling were sufficiently encouraging that further underground work was undertaken. The potential for extending the indicated resources into a deposit of the size and grade presently being exploited elsewhere in the Cordillera appears to be very good. Other gold-silver vein prospects with long exploration histories include the Charlie group in the lower Tchaikazan valley and the Vick property near Taseko River. Both of these areas show strong potential for extending known mineralized zones; a broad area of veined volcanic rocks carrying copper-silver mineralization near the Charlie group has never been fully evaluated. This area was clearly identified by this project's stream-sediment geochemical survey. It can be expected that any successes at Pellaire will stimulate further exploration of these occurrences. The recently discovered mercury mineralization at the Alexis showing west of Chilko Lake closely fits the British Columbia precious metal epithermal deposit model (Panteleyev, 1986). Prospecting completed in the course of this project found previously unknown mineralization and defined a broad area of anomalous levels of indicator elements, considerably extending the zone of high mineral potential. A new discovery of arsenic-bearing vein mineralization was made in a tributary of the Tchaikazan River near both the Pellaire and Charlie group gold veins. Anomalous gold values and a highly favourable geological setting indicate a significant potential at this Twin Creek

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* Adapted from: Glossary of Geology, American Geological Institute.

TABLE 9
SUMMARY OF METALLOGENIC MODELS APPLICABLE TO THE CHILKO LAKE PLANNING AREA

Main Characteristics	Training Tract	Analogous Areas Chilko Lake
A. British Columbia Epithermal Model Framework		
1. Mesothermal Vein Deposits —gold-silver mineralization; arsenic, antimony, copper, lead or zinc may be indicators —relatively deep and higher temperature veins —hydrothermal fluids generally driven by nearby intrusion —quartz vein host emplaced along faults	*Bridge River area* —70 km southwest of Taseko Lakes —foremost gold producing area in B.C.; over 140 million grams gold produced *Warner Pass map area* —immediately east of Taseko Lakes —current exploration for gold veins in same environment as Chilko-Taseko Lakes area *Rossland area* —south-central B.C. —5.5 million tonnes of production grading 13 grams/tonne Au, 17 grams/tonne Ag, 1% Cu.	*Pellaire* —resources of 31 000 tonnes grading 21 grams/tonne Au, 73 grams/tonne Ag. *Charlie group* —gold-silver-bearing quartz veins in fractured volcanics *Vick* —gold-silver-bearing quartz veins in fault zone
2. Epithermal Vein Deposits —gold-silver mineralization; mercury, arsenic or antimony indicators —relatively shallow and lower temperature veins —hydrothermal fluids generally driven by underlying intrusion —quartz vein host emplaced in fractured volcanics or in faults	*Blackdome mine* —70 km east of Taseko Lake —start-up reserves of 184 120 tonnes grading 27.09 grams/tonne Au, 128.9 grams/tonne Ag *Rossland area* —south-central B.C. —10 000 tonnes grading 100 grams/tonne Au *Stewart and Toodoggone areas* —northern B.C. —extensive current exploration on numerous deposits	*Alexis area* —major faults —mercury-copper mineralization —intrusions *Twin Creek* —arsenic-bearing quartz-breccia zones; anomalous gold values —intrusions
3. Porphyry Copper Deposits —large low-grade copper (± gold, molybdenum) mineralization —intrusion related —well fractured and altered hostrocks	*Tyaughton trough* a) Fish Lake deposit —10 km north of Taseko Lake —200 million tonnes grading 0.24% Cu, 0.4 gram/tonne Au, 0.9 gram/tonne Ag b) Poison Mountain deposit —75 km east of Taseko Lake —175 million tonnes grading 0.33% Cu, 0.15% Mo, 0.3 gram/tonne Au.	*Charlie area* —copper-molybdenum mineralization —intrusion related *Tarn Creek* —new discovery —fractured volcanic and intrusive host —copper veinlets
4. Skarn Deposits —gold, tungsten, copper, zinc or molybdenum mineralization typical —intrusion related; hydrothermal fluids alter calcium-bearing rocks —gold only recently recognized as prime commodity	*Nickel Plate mine* —Hedley, southern B.C. —reopened with reserves of 6.5 million tonnes grading 5.1 grams/tonne Au *Tillicum Mountain* —Nakusp, south-central B.C. —gold-silver skarn mineralization currently being developed	*Daisie area* —copper-tungsten mineralization in marble —intrusive stocks
B. Volcanogenic Massive Sulphide Model —copper-zinc-lead-gold-silver mineralization —form as metal-rich strata contemporaneously with volcanic hostrocks —underlain by fractured and weakly mineralized hydrothermal feeder zone	*Britannia mine* —near Squamish B.C. —produced 55 million tonnes grading 1.1% Cu, 0.65% Zn, 6.8 grams/tonne Ag, 0.068 gram/tonne Au. *Seneca deposit* —near Harrison Hot Springs, B.C. —0.8 million tonne grading 0.8% Cu, 6.6% Zn, 0.3% Pb, 58 grams/tonne Ag, 1 gram/tonne Au.	*South of Mt. Goddard to Chilko lakeshore* —favourable geology —anomalous geochemistry *Franklyn Arm* —favourable geology —anomalous geochemistry

prospect. Numerous other smaller vein-type occurrences have been previously documented or are newly discovered in the area; these require further exploration to determine their economic potential.

Two significant porphyry copper environments, similar to the Fish Lake and Poison Mountain deposits to the east, exist in the planning area. Recent exploration in the lower Tchaikazan valley has defined a broad zone of copper and molybdenum mineralization in an area having favourable geological and geophysical characteristics. This mineralization, and the gold veins on the nearby Charlie group, typify a porphyry environment with peripheral precious metal vein mineralization. A large zone of copper mineralization, typical of a porphyry deposit, was discovered at Tarn Creek, north of Yohetta Lake, during fieldwork for this project. Geological mapping confirms a favourable local environment for this deposit type, hence a significant untested potential exists in this area. A zone of higher potential for porphyry deposits lies to the west of Chilko Lake where a number of intrusive stocks and scattered veins carrying copper and molybdenum mineralization have been found.

Skarn-type copper-tungsten mineralization has been known at the head of Franklyn Arm for many years. Many skarn deposits are currently being sucessfully re-evaluated in British Columbia for their gold potential, such as the Nickel Plate mine at Hedley (Ray *et al.* 1987), and all skarn occurrences are of current interest. The geologic environments favourable for this type of deposit appear to be restricted to two areas west of Chilko Lake.

Volcanogenic massive sulphide environments identified in the planning area are considered analogous to areas of known massive sulphide mineralization elsewhere in southwestern British Columbia. The potential for this type of deposit has never been fully recognized near Chilko Lake and there has been little exploration based on this model. Favourable geological and geochemical indicators determined in this study suggest such exploration is warranted.

Specific metallogenic models applicable to the study area are briefly described in the following pages. The essential characteristics of each model are summarized in Table 9; these are related to known deposits in training tracts and analogous environments within the Chilko Lake Planning Area. This information is used to identify 17 areas of greater mineral potential (*see* Figure 23) which are then described in more detail.

METALLOGENIC MODELS APPLICABLE TO THE CHILKO LAKE PLANNING AREA

BRITISH COLUMBIA EPITHERMAL MODEL

The accreted allocthonous terranes forming most of the Chilko Lake Planning Area contain all the geologic settings necessary to produce a variety of intrusion-related and structurally controlled mineral deposits. Island arc volcanic rocks and flanking sedimentary basins, subvolcanic intrusions and younger intrusions emplaced along collision-induced structures provide the hostrocks, hydrothermal fluids, fluid channelways and metal sources necessary for mineralization. Panteleyev (1986) has developed a model for epithermal gold-silver deposits which illustrates their relationship to other major deposit types in volcanic intrusive settings (Figure 22). The model is applicable over a wide vertical range within the crust and therefore across regions that display a variety of mineralization styles representing different levels of erosion. The model provides a tectonic framework in which to discuss individual deposit types. Porphyry copper-molybdenum mineralization forms at depth adjacent to intrusive bodies that provide metal-bearing fluids as well as heat sources to drive the circulation of hydrothermal fluids throughout the system. Skarn and mesothermal vein deposits occur above or adjacent to the intrusions in areas of favourable stratigraphy or structure and the lower temperature epithermal veins and surficial sinter deposits occur higher in the system, in similarly favourable hosts.

MESOTHERMAL AND EPITHERMAL VEIN DEPOSITS

Gold and silver-bearing vein systems are often classified according to their hydrothermal fluid sources and depth of formation. Epithermal deposits develop relatively near the earth's surface (less than 1000 metres) from fluids cooler than 300°C while mesothermal deposits originate from hotter fluids at greater depths. Certain features are common to both deposit types; these include the introduction of a heat source (igneous activity) capable of generating the movement of a large volume of hydrothermal fluid through the depositional environment, the existence of permeability which allows the fluids to circulate (a "plumbing system"), most often in the form of major faults or thoroughly fractured rocks, and finally the physiochemical conditions necessary to precipitate gold and silver minerals. Mineralization most often occurs in quartz veins developed in the enclosing rocks. Base metals such as copper, molybdenum, lead and zinc are more common in mesothermal veins and are prime indicator elements. Mesothermal deposits overlap the porphyry environment and the overlying epithermal vein environment.

Epithermal deposits are generally hosted by fractured volcanic or sedimentary rocks close to fault zones or volcanic vents and well above any major intrusive heat source. As a result the wallrock alteration and vein mineralization, and hence the geochemical indicators, are different from their deeper counterparts; base metals are not associated with classic epithermal gold and silver deposits and only appear in the transition to the underlying mesothermal zone. The upper levels of the epithermal system are characterized by near-surface indicator elements such as mercury, barium or fluorine.

The Bridge River area, 70 kilometres southwest of Taseko Lakes, contains numerous vein deposits from which more than 140 million grams of gold have been produced, making it the most significant gold producing district in the Canadian Cordillera. Since mining first began in the late 1920s numerous workers (*e.g.*, Cairnes, 1937, Joubin, 1948) have studied the mesothermal veins that comprise the majority of occurrences in this mining camp. Leitch and Godwin (1988) indicate the veins developed during a single mineralizing episode contemporaneous with emplacement of the Coast plutonic complex during Late Cretaceous to Early Tertiary time. Further away from the plutonic heat source, veins take on more epithermal characteristics such as extensive mercury mineralization (Woodsworth *et al.*, 1977). The Warner Pass map area immediately east of the Chilko Lake Planning Area has a demonstrated potential for mesothermal to epithermal precious metal deposits associated with intrusions and fault zones (Glover and Schiarizza, 1987). The Bridge River–Warner Pass–Chilko Lake belt comprises a zone of distinctly similar metallogenic features that has historically, and currently, been progressively less explored towards the northwest (*i.e.*, towards Chilko Lake) into areas of poorer access. West of Chilko Lake, near Tatlayoko Lake, gold-bearing quartz veins hosted in faulted sedimentary and volcanic rocks occur close to the contact of the Coast plutonic complex. Most notable of these are the gold-silver-antimony veins at the Morris mine located 15 kilometres west of Chilko Lake (Figures 3, 5). Similar environments, documented elsewhere along much of the eastern margin of the Coast Complex (*e.g.*, Whitesail Lake area, Stewart area), confirm the high mineral potential of this contact zone. The Rossland area in south-central British Columbia represents a similar island arc environment with both mesothermal and epithermal gold mineralization and a significant production history. The epithermal mineralization at Rossland highlights the potential for small but very valuable gold deposits in this environment (10 000 tonnes grading 100 grams per tonne gold; McMillan *et al.*, 1987).

The Blackdome orebody, a 'classic' epithermal deposit that has recently been brought to production (May 1986), is located 70 kilometres east of Taseko Lakes. Gold and silver mineralization is hosted in quartz veins and quartz-breccia zones cutting Eocene volcanics; vein systems are controlled by northeasterly trending structures. Start-up reserves were 184 120 tonnes grading 27.09 grams of gold and 128.9 grams of silver per tonne; published reserves as of December 1987 were 222 820 tonnes of somewhat lower grade, after mining 108 700 tonnes. These figures highlight how additional reserves are established once underground developments commence. Base metals are noticeably absent; gold, arsenic and antimony show a strong correlation in wallrock samples. The deposit is thought to have developed above a large intrusive system similar to that at Poison Mountain (see porphyry model discussion). The Toodoggone area of northern British Columbia represents another area of widespread epithermal precious metal mineralization that is currently undergoing extensive exploration and mine development.

PORPHYRY COPPER DEPOSITS

Porphyry copper deposits are large accumulations of usually low-grade mineralization that is spatially and genetically related to igneous intrusions (McMillan and Panteleyev, 1980). The intrusive event and the large hydrothermal system it generates are responsible for intense fracturing of both the intrusive and surrounding rocks. Hydrothermal fluids circulating through the fractured rocks develop a widespread zoned sequence of mineralization and alteration outward from the intrusive heat source. Many intrusions are localized along major fault zones, often at their intersections. Copper and molybdenum mineralization, often with low grade but economically important gold and silver values, occurs throughout the fractured hostrocks. Precious metal vein deposits often occur on the outer edges of these hydrothermal systems. Geochemical indicators are primarily copper and molybdenum; gold and mercury are also useful in some areas, as are zinc and lead if peripheral veins carrying base metals are present. Prospecting indicators include highly altered and fractured rocks associated with intrusive stocks or dike swarms and signs of dispersed copper mineralization.

Porphyry deposits contain the vast majority of British Columbia's copper reserves and in recent years a significant proportion of British Columbia's gold production has been won as a byproduct from porphyry copper mines. Two porphyry deposits occur within the Tyaughton trough in a geological setting comparable to that mapped in the Chilko Lake Planning Area. The Fish Lake copper-gold porphyry deposit, located 10 kilometres north of Taseko Lakes, contains 200 million tonnes of material grading 0.24 per cent copper, 0.4 gram per tonne gold and 0.9 gram per tonne silver (Canadian Mines Handbook, 1984). It is associated with a Late Cretaceous intrusive stock and dike complex (Wolfhard, 1976) cutting sediments and volcanics equivalent to Units UK_S and UK_V in this study.

Approximately 75 kilometres east of Taseko Lakes the Poison Mountain porphyry deposit contains approximately 175 million tonnes averaging 0.33 per cent copper, 0.015 per cent molybdenum and 0.3 gram per tonne of gold (Seraphim and Rainboth, 1976). Here, three porphyritic intrusions cut sediments deposited in the Tyaughton trough at the same time as rocks of Unit LK_{TC} in this study. Copper anomalies in stream sediments clearly outline the mineralized zone. The main intrusions and numerous dikes associated with both deposits are structurally controlled by northwest-trending faults related to the major Yalakom fault and younger north to northeast-trending structures that may have been significant in localizing the intrusive rocks. Although these deposits are currently subeconomic they represent significant mineral resources to be inventoried for the future. Another porphyry occurrence, the Banner or Chita prospect, is located immediately east of the Chilko Lake Planning area on the east side of Taseko Lakes. Here disseminated copper mineralization occurs throughout an area of brecciated and highly altered feldspar porphyry intrusive. North to northeast-trending faults are again present. This prospect has seen a limited amount of exploration to date.

SKARN DEPOSITS

Skarn deposits develop when hydrothermal solutions driven by a nearby intrusive invade, alter and mineralize calcium-bearing rocks such as limestones, dolomites or less pure calcareous sediments. Skarns usually occur close to intrusive contacts but they may develop many kilometres away as fracture controlled vein-like bodies cutting across the favourable horizon. A distinctive calcsilicate alteration assemblage is developed. Economic mineralization varies with the type of deposit but typically may include tungsten, copper, zinc or molybdenum. Recently, gold-bearing skarn deposits have been recognized as an attractive exploration target in the Canadian Cordillera, and many skarn prospects are being re-evaluated for their precious metal potential. Interest in gold-bearing skarns has been stimulated by the recent reopening of the Nickel Plate mine near Hedley, where mineable reserves are 8.9 million tonnes of ore grading 4.56

grams gold per tonne (Mascot Gold Mines Limited, news release, November 18, 1987), and the discovery of skarns containing gold and silver mineralization at Tillicum Mountain, south of Nakusp in 1980. There are no known economic skarn deposits close to and in the same geologic terrane as the Chilko Lake Planning Area, however as skarn mineralization is known in the area an evaluation of its potential must be considered.

VOLCANOGENIC MASSIVE SULPHIDE MODEL

Volcanogenic massive sulphide deposits, formed in island arc environments, have a close genetic relationship to felsic submarine volcanism; the metallic mineralization precipitates out of hydrothermal fluids venting on the seafloor during the waning stages of a volcanic cycle. Mineralization, occurring in pods or lenses within the volcanic-sedimentary strata, generally consists of layers of copper or zinc-rich ore. Additional recoverable commodities may include lead, silver, gold, tin, cadmium, antimony, bismuth, selenium, indium and other light metals. Barite horizons or highly siliceous horizons commonly overlie or surround the mineralization while a pipe-like zone of copper-bearing quartz-stockwork mineralization often marks the conduit through which the hydrothermal fluids vented to the surface. Pyrite is the most common sulphide mineral, occurring both within the ore and in the surrounding siliceous zones; pyrrhotite is often present in the stockwork and lower ore zones. The main geochemical indicators for these deposits are copper, zinc, lead and silver. Mineralogical or prospecting indicators include felsic volcanic horizons with gossanous (rusty) zones carrying pyrite, pyrrhotite and copper mineralization; associated copper-bearing quartz veinlets or siliceous horizons are also significant.

This model is largely based on detailed research on relatively young and undeformed 'Kuroko' deposits in Japan (Lambert and Sato, 1974) and has been applied to many similar deposits in Canada. Kuroko-type deposits are important producers or past-producers in British Columbia and are undergoing considerable current exploration (McMillan *et al.*, 1987). The Britannia orebody near Squamish was such a deposit (Payne *et al.*, 1980) and yielded 55 million tonnes of copper-zinc-silver-gold ore between 1905 and 1974. This deposit was virtually mined out before its volcanogenic nature was recognized (Sutherland-Brown, 1975). The host-rocks at Britannia are very similar in age and character to the Lower Cretaceous rocks of the Chilko Lake Planning Area. The massive sulphide potential of volcanic island arc rocks near Harrison Lake, considered correlative with those of the Chilko Lake area, is highlighted by the Seneca deposit, a Kuroko-type deposit of probable Jurassic age (Thompson, 1972), and the copper-zinc-gold mineralization immediately to the north at Fire Mountain (Assessment Report 11796). These areas (*see* Figure 8) serve as volcanogenic massive sulphide training tracts for the Chilko Lake Planning Area. The Westmin deposits on Vancouver Island, containing approximately 20 million tonnes of gold-silver-copper-zinc-lead-cadmium mineralization in a number or orebodies, further confirm the value of volcanogenic massive sulphides in island arc settings in British Columbia.

MINERAL DEPOSITS OF THE CHILKO LAKE PLANNING AREA

The mineral deposits previously known or recently discovered in the Chilko Lake Planning Area will be discussed within the metallogenic model framework established above. Some of the deposits are sufficiently well understood to confidently apply a metallogenic model whereas others are poorly known mineral occurrences where more interpretation is required to fit the known characteristics to a model. Furthermore, some areas display characteristics of more than one type of deposit and represent a transition zone between deposits within an overall metallogenic model (*e.g.*, porphyry and mesothermal vein occurrences). In these cases the potential for both deposit types must be considered.

MINERAL POTENTIAL AS INDICATED BY MINERAL OCCURRENCES

There are at least a dozen important mineral occurrences now documented in the planning area. These range from a deposit with indicated resources to mineral showings with many features that can be directly related to a metallogenic model in order to provide exploration guidelines. There are many more areas where minor veining and anomalous lithogeochemistry occur in favourable geological environments. Figure 23 illustrates areas of higher mineral potential as defined by the distribution of these occurrences. The majority of them are presently covered by mineral claims and are undergoing exploration. Similarities between the areas of higher mineral potential delineated in Figure 19 (lithogeochemical indicators) and Figure 23 are to be expected as the data for both figures are obtained from lithogeochemical samples. Figure 23 also includes lithogeochemical and mineral occurrence information from assessment reports.

MESOTHERMAL AND EPITHERMAL VEIN ENVIRONMENTS

PELLAIRE PROPERTY (LORD RIVER GOLD MINE) — (MINFILE 92O 045)

Gold-bearing quartz veins were discovered by prospectors in 1936 in the Falls River valley, a tributary of the Lord River. The Minister of Mines Annual Report for the following year recorded the discovery of five veins up to 2.4 metres wide with selected samples returning significant precious metal assays (up to 400 grams per tonne gold and 1345 grams per tonne silver; B.C. Minister of Mines Annual Report, 1937). At this time the property was known by the names Hido or Pellaire. Sporadic exploration work was conducted in the 1930s and 1940s including diamond drilling and some underground development. An initial calculation indicated ore reserves were in the order of 31 000 tonnes grading 21 grams gold and 73 grams silver per tonne (Skerl, 1947). In the 1970s and early 1980s, Silver Standard Mines Limited in association with Lord River Gold Mines Limited, rehabilitated the underground workings and checked the previous results. A new adit was driven but stopped short of the vein. In 1987 a re-evaluation of the potential of the property was

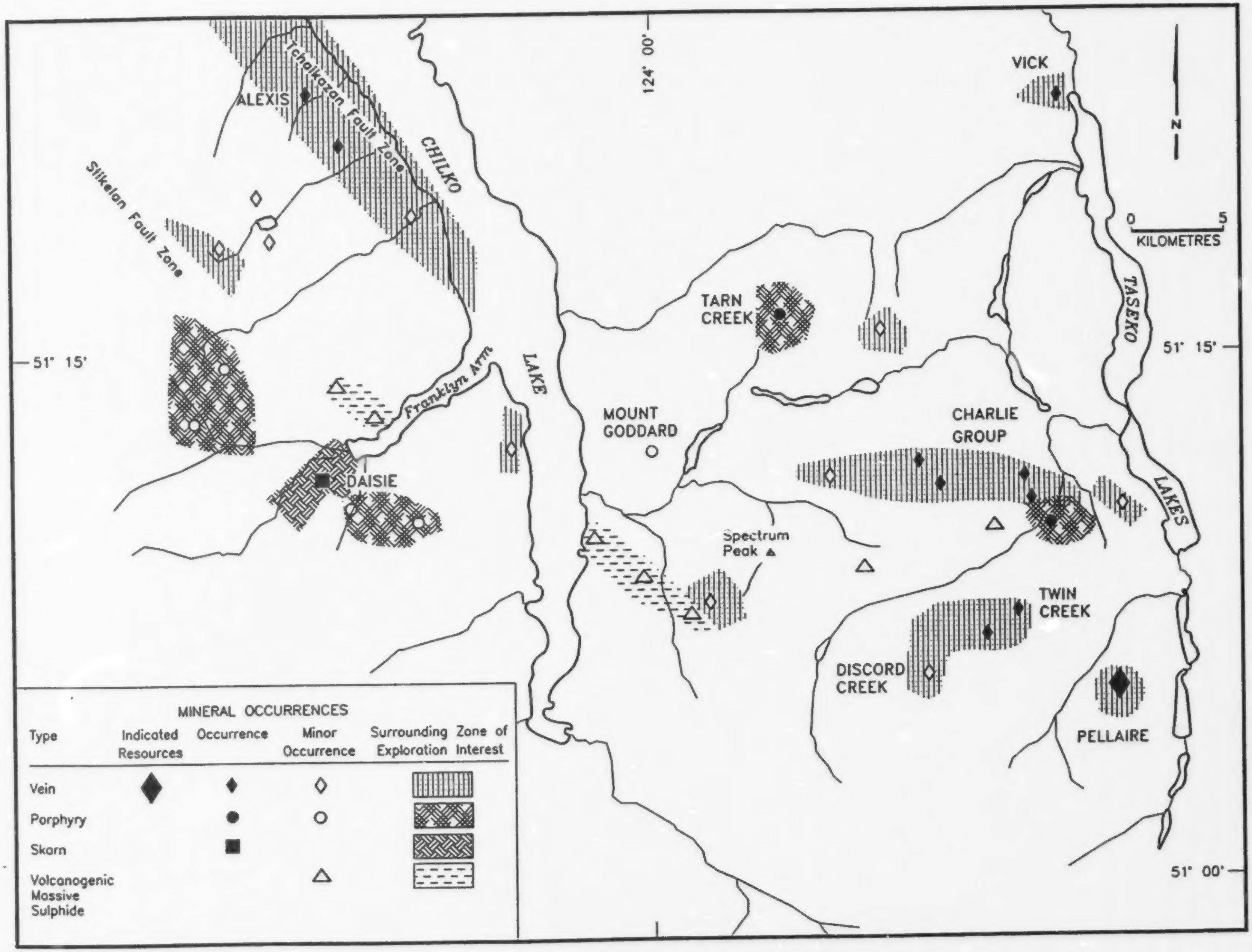

VICK
124° 00'
ALEXIS
Tchaikazan Fault Zone
CHILKO
Stikelan Fault Zone
0 5
KILOMETRES
N
TASEKO
TARN CREEK
51° 15'
51° 15'
LAKE
Franklyn Arm
MOUNT GODDARD
CHARLIE GROUP
DAISIE
LAKES
Spectrum Peak
TWIN CREEK
DISCORD CREEK
PELLAIRE
51° 00'
MINERAL OCCURRENCES
Type
Indicated Resources
Occurrence
Minor Occurrence
Surrounding Zone of Exploration Interest
Vein
Porphyry
Skarn
Volcanogenic Massive Sulphide

Figure 23. Zones of greater mineral potential as defined by the distribution of mineral occurrences.

completed and a program of diamond drilling was recommended to determine the continuity of the known veins (Saunders, 1987). This work was undertaken late in 1987 and the results are not yet known, however the initial results were sufficiently encouraging for further immediate underground development to be recommended (George Cross Newsletter, September 28,1987).

The quartz veins are hosted primarily within a lobe of granodiorite of the Coast plutonic complex extending northwards into volcanic and sedimentary rocks of Unit LK$_{TC}$ (Figure 24; Plate 18). The volcanic rocks include both flows and pyroclastics that are well altered to a siliceous hornfels; sedimentary lithologies are similarly hornfelsed but are not as extensive. Five of the numerous veins on the property have some continuity and have returned significant gold assays (Saunders, 1987). Limonite staining and casts of pyrite crystals are common. Chalcopyrite, galena, rare visible gold and native antimony, and hessite, a gold-bearing silver telluride, have been identified in the veins (Warren, 1947). Contacts of the veins may be sharp or contain clay gouge; in places wallrocks are intensely silicified and carry pyrite. Individual very high gold assays have been documented in every report on the property. Table 10 provides the analyses determined in this study from the samples located in Figure 24.

At present insufficient mapping or drilling has been completed to fully understand the genesis of this deposit or to determine if the veins extend significantly into the surrounding volcanic rocks. As the veins outcrop on the crest of a steep sided ridge in the granodiorite (Plate 18), potential for additional reserves is limited to the downward extensions of the veins and the favourable hostrock. Should the granodiorite contact flare outward away from the ridge at depth there is greater potential for lateral extension of the veins. Saunders projected the vein system to the valley floor from the ridge crest to calculate an estimate of potential resources in the ground; he suggests that there is a reasonable expectation for the deposit to contain approximately 270 000 tonnes grading in excess of 17 grams gold per tonne. This exercise is an estimate based on various assumptions that are currently being tested by core drilling. It illustrates the difficulty in determining the true mineral potential of a deposit.

The Pellaire deposit contains many elements of the mesothermal vein model, including well-fractured hostrocks, a hydrothermal heat source, evidence for widespread circulation of hydrothermal fluids, and proven significant mineralization. This prospect is the only deposit in the Chilko Lake Planning Area with a currently indicated resource in the ground; the potential for identifying additional mineralization appears to be very good. The mineral potential of this

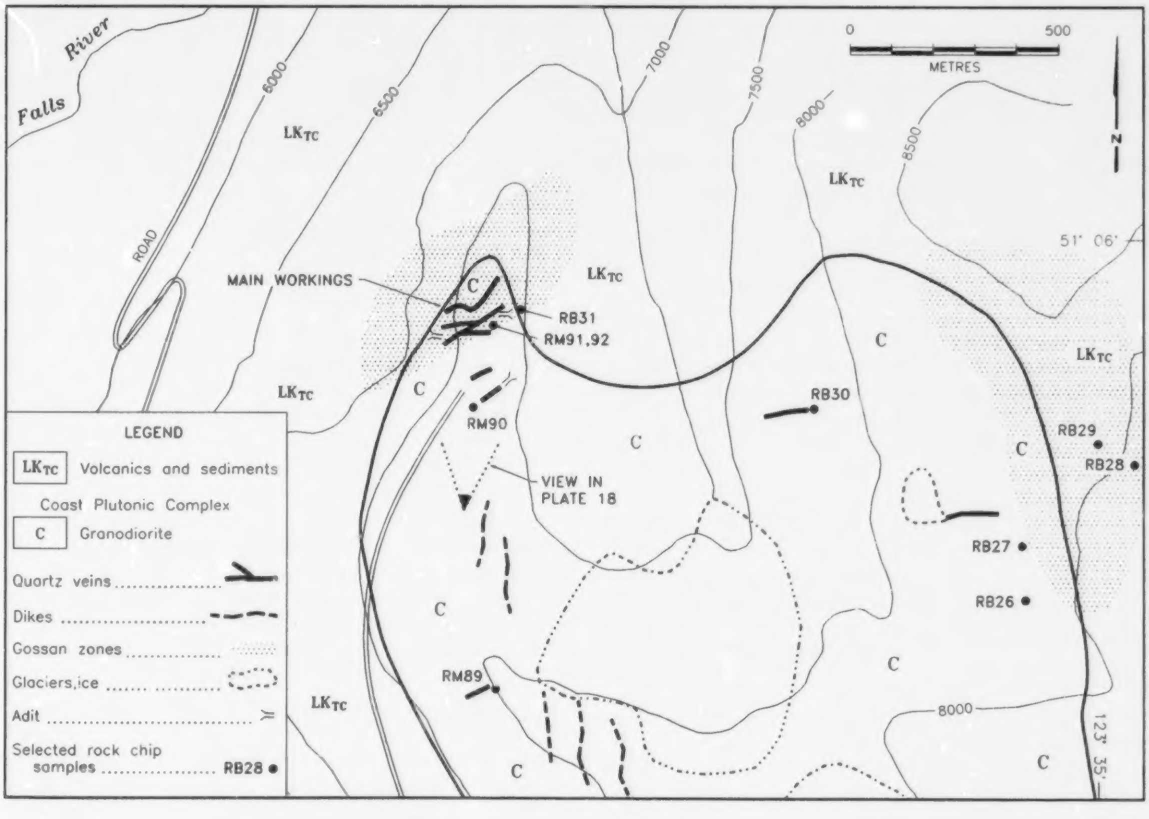


Figure 24. Geological setting of the Pellaire gold occurrence.

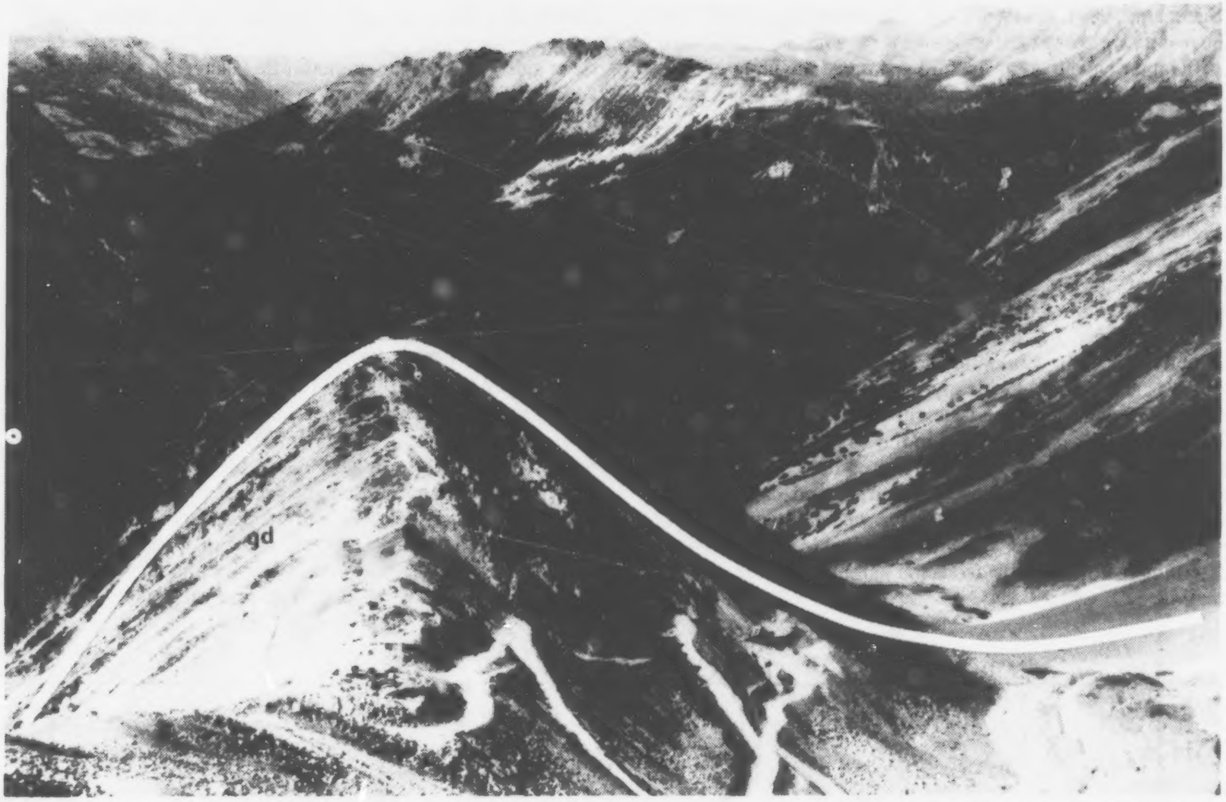


Plate 18. Pellaire gold prospect: contact between granodiorite (gd) and volcanics crosses the distant end of the ridge; the veins trend across the ridge in the granodiorite. Adits are located downslope to the right (arrow) and left. View looking north, Taseko Lakes valley in top right corner.

TABLE 10
SELECTED GEOCHEMICAL ANALYSES FROM THE PELLAIRE AREA

Sample Number	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Mo ppm	Mn ppm	Fe %	Hg ppb	Sb ppm	Bi ppm
RB 26	<20	<0.3	52	10	22	35	<10	<10	90	1.87	360	<20	<5
RB 27	<20	<0.3	41	<10	52	38	12	<10	342	2.33	185	<20	<5
RB 28	<20	<0.3	19	<10	54	40	<10	<10	307	1.44	95	<20	<5
RB 29	22	<0.3	395	10	186	40	19	<10	1900	6.71	825	<20	<5
RB 30	43	<0.3	145	<10	14	34	<10	<10	80	1.41	490	<20	<5
RB 31	70*	180	850	<10	5	71	<10	17	24	5.07	1800	<20	20
RM 89	2.4*	5.0	86	<10	9	63	<10	<10	36	1.06	295	32	14
RM 90	7.2*	55	800	42	114	82	<10	79	27	5.15	430	26	31
RM 91	251	2.0	16	<10	<5	144	<10	<10	22	0.66	55	32	<5
RM 92	1.4*	1.0	13	24	58	41	9	<10	294	2.52	550	<20	<5

* Gold values in parts per million.

particular area must be considered to be very high. This deposit also serves to illustrate the general high mineral potential along the contact of the Coast plutonic complex in the planning area.

CHARLIE GROUP AREA (MINFILE 92O 043)
LOWER TCHAIKAZAN VALLEY

A prospecting party exploring the Tchaikazan valley in 1945 discovered quartz veins carrying gold-silver mineralization high on a steep mountain slope. Although only minor amounts of sulphide mineralization (predominantly pyrite) were observed in the veins, assays from a panned sulphide concentrate returned "many ounces of gold and more than 50 ounces of silver" (Warren, 1947). The occurrence was referred to as the Charlie group. Further studies by Warren identified minor amounts of chalcopyrite, galena, sphalerite, arsenopyrite, tetrahedrite and a number of tellurides including hessite (gold-bearing silver telluride), altaite (lead telluride), and wehrlite (silver-bearing bismuth telluride). Six Crown-granted mineral claims established over this mineralization still exist today. More recently this property has been included within a much larger exploration project focused on locating a porphyry copper deposit (*see* Porphyry Deposit Environments — Charlie area).

The veins are hosted by volcanic and sedimentary rocks of Unit LK_{TC} in an an area of strong faulting (Figure 25). Volcanic lithologies predominate and are comprised of feldspar crystal tuffs, lithic fragmentals, and some flow rocks with chloritic amygdules. Argillaceous sediments are a minor component of the succession. Chlorite and serpentine alteration occurs along fractures. These rocks are cut by a number of quartz diorite dikes, possibly related to a larger intrusive below the floor of the Tchaikazan valley. A prominent limonitic zone on the bluff in the vicinity of the quartz veins is due to pyrite-pyrrhotite mineralization associated with a siliceous hornfels alteration of the volcanics and sediments. These rocks are also strongly fractured and quartz-epidote alteration along the fractures is common. Silicified vein breccias are present locally.

A number of quartz veins were found while prospecting this area during this project. The largest veins, presumed to be those originally located by Warren, are up to 15 centimetres wide, dip gently to moderately (20 to 40°) northwards into the slope, and are fairly continous. The Charlie vein outcrops at approximately 2100 metres (7000 feet) elevation. The vein outcrops intermittently within a structure that can be traced from beneath a talus slope for a few hundred metres to the east where it can be seen extending across an inaccessible face. The Big vein lies above 2300 metres (7500 feet) elevation in a similar structure. Other veins with similar attitudes were noted and sampled; anomalously high levels of gold, silver, lead and arsenic were determined. Geochemical analyses are compiled in Table 11.

Industry exploration of a large claim block centred on the Charlie group outlined numerous areas of copper mineralization, often with significant silver and some anomalous gold values, in a structural setting similar to that of the Charlie group. Immediately east of the Charlie group on Avalanche Creek (Figure 25), a selected sample from a narrow quartz vein is reported to contain 12 grams gold and 308 grams silver per tonne and 13.7 per cent copper (Assessment Report 10774). Stream-sediment samples collected from this creek all returned anomalous levels of gold. A rock-chip sample from a similar vein in the creek to the north returned 28 grams silver per tonne, 1.8 per cent copper and anomalous zinc, mercury, arsenic and antimony. Structurally controlled copper-silver mineralization has been located in brecciated and fractured volcanic rocks on ridge crests approximately 3 to 5 kilometres northwest of the Charlie group. Many of the samples collected here by industry contain hundreds of grams per tonne silver. In this area fracture planes, quartz-carbonate veins, and quartz stockwork or breccia zones contain malachite, azurite, chalcopyrite, some native copper and possibly native silver (Assessment Report 10774). A number of significant analyses are included in Table 11. Note that the stream-sediment geochemical survey discussed in Chapter 3 highlighted numerous copper anomalies in this area.

The Charlie group and the surrounding area of fractured and veined volcanic rocks display many of the characteristics of a mesothermal to epithermal vein environment. A number of intrusive bodies are evident at surface and there are geophysical indications of a larger intrusive beneath the Tchaikazan valley. Major transcurrent faults border the area of known mineralization to the north and south; smaller faults and fractures related to movement on these structures cut the volcanic hostrocks. Local vein-stockwork and breccia zones, and vuggy quartz-carbonate veining, indicate hydrothermal activity within an open-space fracture system. The documented mineralization and anomalous stream-sediment and rock geochemistry confirm the high potential of the area. Most of the detailed exploration work to date has been based on a porphyry deposit model and concentrated in the Tchaikazan valley; the vein potential has not been fully evaluated and is considered very good.

VICK GOLD-SILVER VEINS
(MINFILE 92O 027)
TASEKO RIVER

A prominent fault exposed on a steep mountain ridge at the northern end of Taseko Lakes was found to contain gold and silver-bearing quartz-sulphide veins in 1932 (B.C. Minister of Mines Annual Report, 1935). Two exploration adits were driven in 1935. The veins range from a few centimetres to over 1.5 metres in width and assays of 20 to over 100 grams of gold per tonne across 30-centimetre widths were common (Dolmage, 1939). Interest in the property was renewed in the late 1960s and 1970s and attempts were made to trace the vein systems along strike. More recently geochemical and geophysical surveys have been used to explore for extensions of the mineralized structures in the alpine bowl to the west of the discovery showings.

The rocks hosting the veins are Upper Cretaceous volcanic pyroclastics and flows of Unit UK_v (Figure 5). Tipper (1978) mapped a major northwest-trending fault cutting these rocks along the face of the mountain. In the vicinity of the showings a branching series of diorite dikes roughly parallels the northeast-trending mineralized fault zone. Mineralization occurs within a system of steeply dipping quartz-sulphide fissure veins that vary considerably in width and outcrop

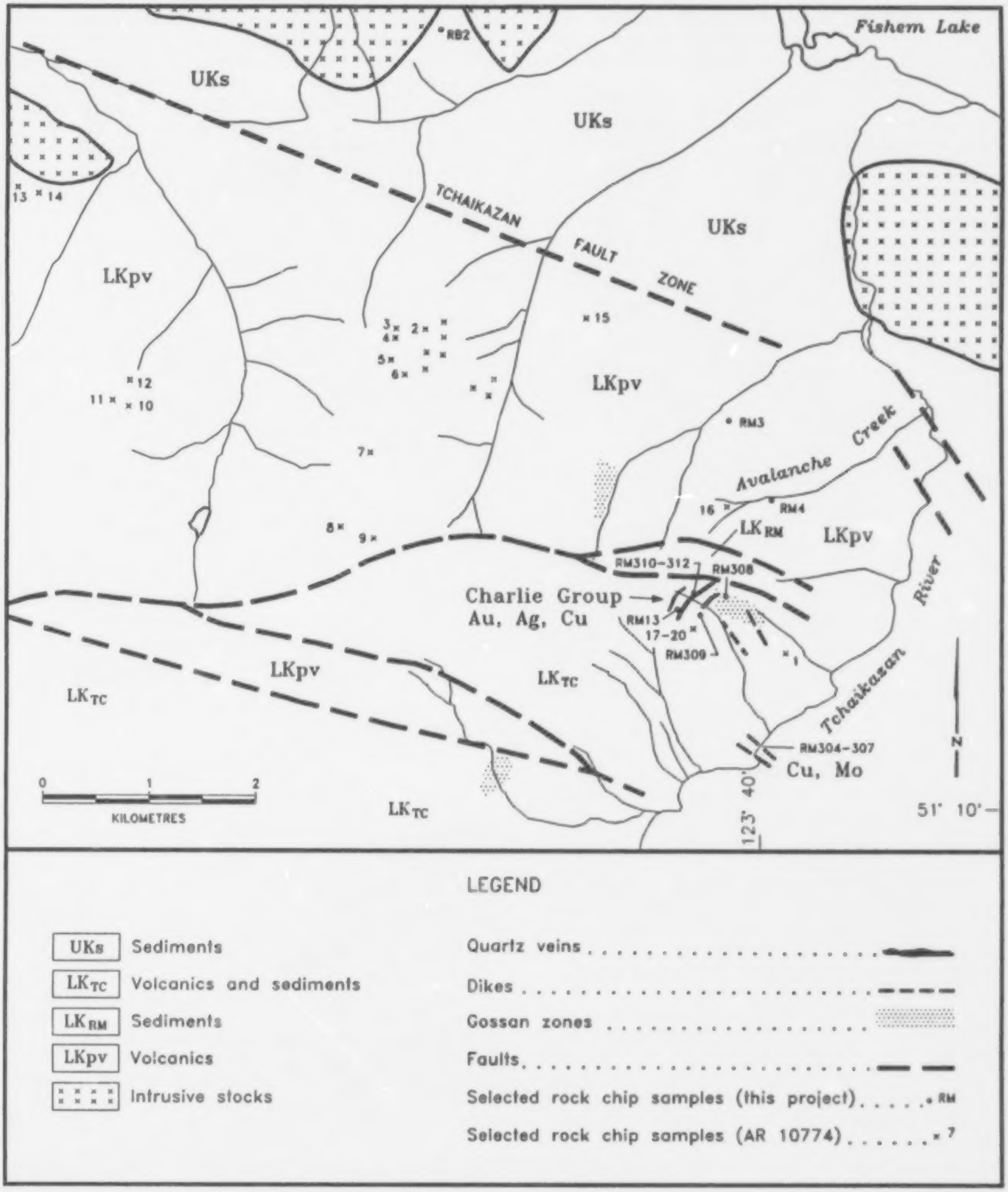

Fishem Lake
RB2
UKs
UKs
UKs
13
14
TCHAIKAZAN FAULT ZONE
LKpv
LKpv
LKpv
LKpv
15
3
4
2
5
6
12
11
10
7
8
9
RM3
Avalanche Creek
16
RM4
LKRM
RM310-312
RM308
Charlie Group Au, Ag, Cu
RM13
17-20
RM309
1
LKTC
LKTC
LKTC
Tchaikazan River
RM304-307
Cu, Mo
123° 40'
51° 10'
N
0
1
2
KILOMETRES
LEGEND
UKs Sediments
LKTC Volcanics and sediments
LKRM Sediments
LKpv Volcanics
Intrusive stocks
Quartz veins
Dikes
Gossan zones
Faults
Selected rock chip samples (this project) RM
Selected rock chip samples (AR 10774) 7

Figure 25. Geological setting of the Charlie Group area.

TABLE 11
SELECTED LITHOGEOCHEMICAL ANALYSES FROM THE CHARLIE GROUP AREA

Sample Number	Au** ppb	Ag ppm	Cu* ppm	Pb ppm	Zn* ppm	Mo* ppm	Fe %	Hg** ppb	Sb ppm	As ppm
RM 3	<20	28	1.77	140	0.48	<10	3.83	11.0	127	488
RM 4	<20	<0.3	122	<10	97	<10	6.51	1.6	<20	43
RM 304	<20	1.0	0.35	<10	11	66	1.3	<20	<20	<10
RM 305	50	2.0	0.52	<10	19	0.23	1.7	<20	<20	<10
RM 306	<20	1.0	0.24	47	72	187	5.1	78	<20	<10
RM 307	40	1.0	0.58	12	43	0.12	5.2	<20	<20	<10
RM 308	<20	<0.3	28	20	34	<10	1.5	30	<20	<10
RM 309	60	0.5	111	20	127	<10	4.5	<20	<20	124
RM 310	3.9	40	171	956	253	73	2.2	41	24	11
RM 311	1.9	21	150	422	91	20	2.2	184	29	99
RM 312	<20	<0.3	31	20	95	<10	6.2	42	<20	49
RM 313	<20	<0.3	17	14	95	32	5.3	<20	<20	106
RM 314	<20	<0.3	21	<10	76	<10	6.3	180	<20	222
RB 2	61	0.4	415	<10	320	<10	13.6	3.0	315	410

* Copper, molybdenum and zinc values with a decimal point are expressed in per cent.
** Gold and mercury values with a decimal point are expressed in parts per million.

SELECTED ASSAYS FROM ASSESSMENT REPORT 10774

Sample Number	Au ppb	Ag ppm	Cu %
1	0.4	21	1.4
2	—	350	1.6
3	—	112	0.5
4	—	376	0.1
5	0.2	360	2.0
6	—	367	0.4
7	0.8	980	12.3
8	—	215	3.2
9	—	18	3.0
10	—	45	1.3
11	0.7	84	9.4
12	—	35	4.0
13	0.6	4	0.6
14	0.5	5	0.5
15	—	38	2.71
16	12	308	13.7
17	5	158	1.6
18	19	94	0.1
19	1.9	4800	21.4
20	13	111	0.1

TABLE 12
SELECTED GEOCHEMICAL ANALYSES FROM THE VICK PROPERTY

Sample Number	Au** ppb	Ag ppm	Cu* ppm	Pb ppm	Zn ppm	Mo ppm	Fe %	Hg** ppb	Sb ppm	As ppm	Bi* ppm
RM 301	72.0	86	0.20	37	229	<10	16.5	7.0	26	560	0.12
RM 302	760	1.0	161	10	60	<10	4.9	710	<20	38	17
RM 303	180	<0.3	0.54	18	240	<10	8.0	134	<20	<10	10

* Copper and bismuth values with a decimal point are expressed in per cent.
** Gold and mercury values with a decimal point are expressed in parts per million.

intermittently across the steep terrain partially covered by talus and persistent snow and ice. The veins consist of ribboned and vuggy quartz, often with iron carbonates; pyrite and chalcopyrite in bands parallel to the walls are seen locally; malachite is common. The wallrocks are usually moderately to strongly silicified and brecciated. Significant precious metal assays are generally associated with sulphide-rich sections of the veins. Three samples were collected from accessible outcrops of vein during a brief examination of this prospect. Analyses shown in Table 12 support results reported in the literature. Sample RM 301, containing 72 grams per tonne gold and 0.12 per cent bismuth, was taken from a strongly silicified and brecciated section of a vein carrying considerable pyrite and some chalcopyrite.

Again the criteria for a mesothermal to epithermal vein model are present. A major northwest-trending fault lies adjacent to the prospect and the veins are contained in a transverse structure which has been invaded by dikes. Fracturing, brecciation and open-space filling of a competent volcanic unit are evident. Significant mineralization has been documented and reconnaissance geophysical surveys suggest the mineralized structures extend well to the west. Exploration conducted in 1987 reportedly identified 17 new gold-bearing veins as well as geochemical anomalies suggesting further vein extensions (George Cross Newsletter, No. 95, May 17, 1988). The mineral potential of this prospect, located on the extreme northeast periphery of the Chilko Lake Planning Area, is considered high.

ALEXIS AREA (MINFILE 92N 045)
CHILKO LAKE

The Alexis claims covering a zone of copper-mercury mineralization on an open ridge crest overlooking Chilko Lake were first staked in 1980. Since that time geological mapping, geochemical sampling and reconnaissance geophysical surveys have been conducted over the property; in addition 287 metres of core drilling has been completed in three holes. This work confirmed a broad area of anomalously high mercury, arsenic, antimony, copper and zinc lithogeochemical values occurring within silicified fractures and pervasive carbonate alteration zones along a segment of the Tchaikazan fault zone. Visible mineralization is concentrated at the "Knob showing" and anomalous arsenic geochemistry defines the "Ridge showing" slightly to the west (Plate 19).

The host rocks in the area comprise both Lower and Upper Cretaceous volcanic and sedimentary lithologies (Units $LK_{mv,ms}$ and UK_v) cut by the broad Tchaikazan fault zone (Figure 5). The breadth of this fault zone probably extends from the area of the showings downslope to Chilko Lake; along strike it trends southeastward along the slopes west of the lake and extends through Stikelan Pass to the northwest. Up to 30 kilometres of strike-slip movement has been suggested on this fault (Tipper, 1968); splays and small crossfaults are common within the zone. Numerous discontinuous diorite and felsite dikes have invaded the fault zone in this area (Figure 26). Pervasive bleaching and carbonate alteration zones, some in excess of 100 metres wide, follow the fault zone and surround all known showings. Within the carbonate alteration, localized zones of moderate to intense silicification are accompanied by quartz veining and brecciation. Silicified veinlets or quartz-calcite vein breccia with a brown ankeritic matrix carry most of the mineralization. Clay alteration occurs in some fractures and in feldspar phenocrysts in the volcanic tuffs. Minerals identified in the showings include tennantite, azurite, malachite, cinnabar, realgar, stibnite, hematite, aragonite and dickite.

Prospecting along strike in the fault zone in this project led to the discovery of a new zone of similar copper-mercury mineralization 3 kilometres to the southeast of the Knob showing, and traces of mercury mineralization 1 kilometre to the northwest, extending the length of the mineralized system well beyong that previously reported. Both of these new showings are adjacent to intrusive rocks.

As discussed in Chapter 3, the stream-sediment geochemistry of this area is highly anomalous in mercury; lithogeochemical sampling has confirmed the high mercury, arsenic, copper, and antimony levels in bedrock. Three samples taken from the Knob showing, representing visibly 'intense', 'moderate' and 'weak' mineralization, returned mercury values of 0.45, 0.22 and 0.06 per cent respectively. Arsenic, antimony copper and silver values showed similar trends. Gold values tend to be low, however a single sample from the new southernmost showing returned 455 ppb and gives more encouragement for further exploration. The locations of rock sampling sites are shown in Figure 26 and the analytical results are given in Table 13.

Mineralization at Alexis fits the upper zones of the British Columbia epithermal model for precious metal deposits. The extensive fracturing and faulting developed in the broad Tchaikazan fault zone provide the permeable channelways necessary for movement of mineralizing fluids. Numerous dikes indicate an intrusive heat source is present and as all showings are near intrusions it appears that they are significant in the genesis of the deposits. The mercury, antimony and arsenic mineralization is typical of the upper levels of an epithermal system. The diamond drilling completed to date has been shallow and cannot be considered a true test of the precious metal potential deeper in the system. Similarly the geophysical surveys only explored to relatively shallow depths. In the few years since the discovery of this prospect only a small part of the epithermal system has been tested. No detailed prospecting has been completed across the full width of the fault zone, particularly at lower elevations below timberline. Further encouragement from this area may be gained by probing the fault system to greater depths or by searching along strike for areas of greater intrusive activity with related hydrothermal alteration and mineralization. The mineral potential of the Alexis area is high.

TWIN CREEK AREA
TCHAIKAZAN VALLEY

A series of intensely silicified fracture zones, one of which carries considerable realgar mineralization, was found in 1986 (McLaren, 1987a) on the banks of a creek in a broad drift-covered valley that drains northward into the Tchaikazan River. This valley, here referred to as Twin Creek

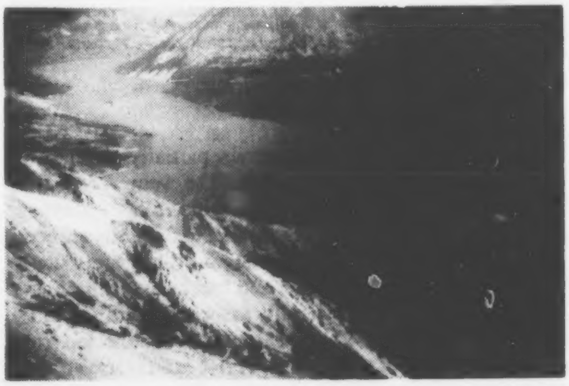


Plate 19. Alexis mercury-copper-arsenic mineralized zones (Knob and Ridge showings) overlooking Chilko Lake.

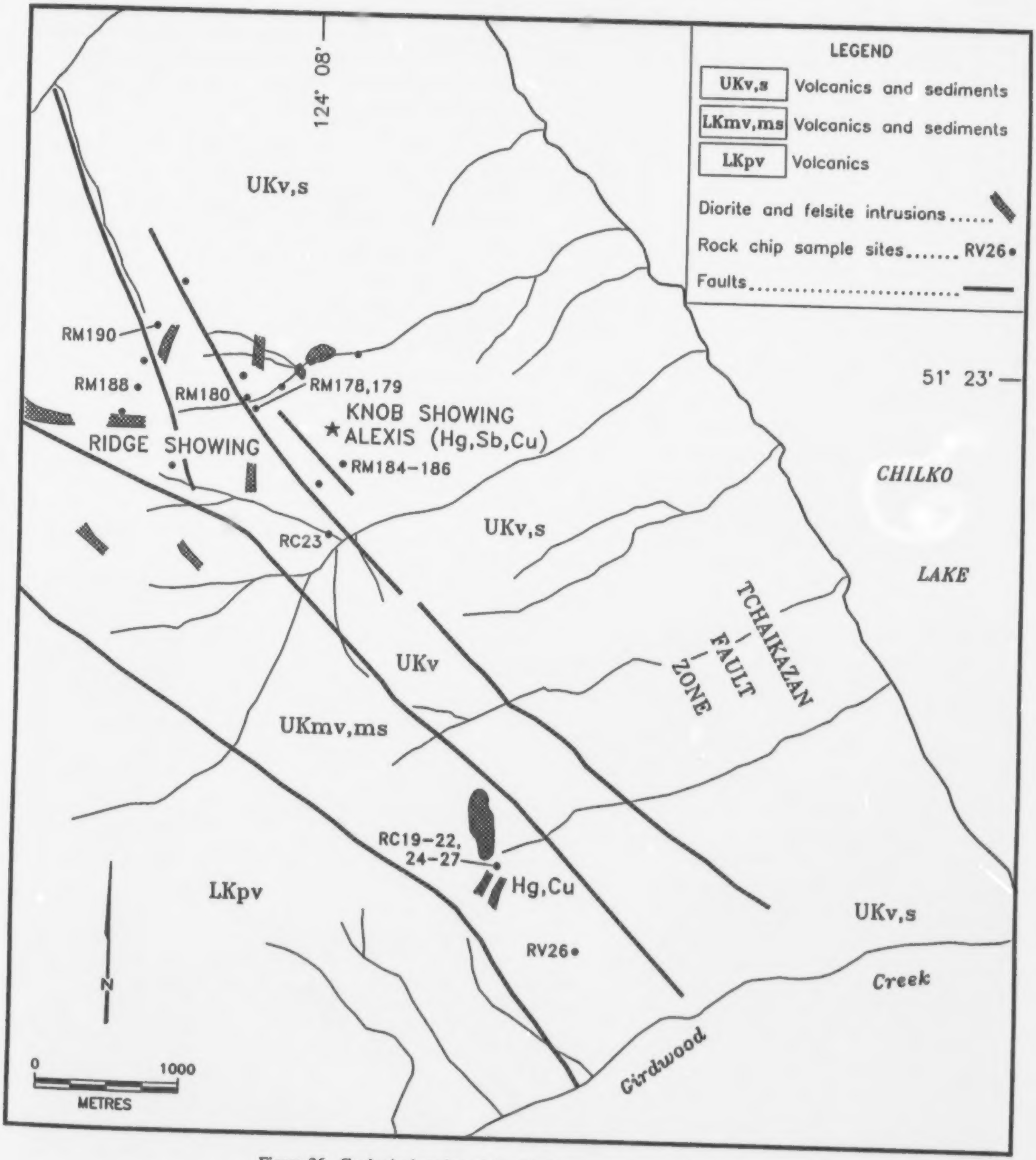

LEGEND
UKv,s Volcanics and sediments
LKmv,ms Volcanics and sediments
LKpv Volcanics
Diorite and felsite intrusions
Rock chip sample sites RV26
Faults
124° 08'
51° 23'
UKv,s
RM190
RM188
RM180
RM178,179
KNOB SHOWING
ALEXIS (Hg,Sb,Cu)
RIDGE SHOWING
RM184-186
RC23
UKv,s
CHILKO
LAKE
TCHAIKAZAN FAULT ZONE
UKv
UKmv,ms
RC19-22, 24-27
Hg,Cu
LKpv
UKv,s
RV26
Creek
Girdwood
N
0
1000
METRES

Figure 26. Geological setting of the Alexis mercury-copper showings.

TABLE 13
SELECTED LITHOGEOCHEMICAL ANALYSES FROM THE ALEXIS AREA

Sample Number	Au ppb	Ag ppm	Cu* ppm	Pb ppm	Zn ppm	Mo ppm	Fe %	Hg ppm	Sb* ppm	As ppm
RM 178	<20	<0.3	50	20	152	<10	5.3	2.10	<20	<40
RM 179	<20	<0.3	18	18	160	<10	5.2	1.35	<20	<40
RM 180	138	<0.3	11	<10	143	<10	8.1	2.08	38	393
RM 184	<20	2.0	300	35	179	<10	6.1	634	60	40
RM 185	<20	6.0	0.28	13	184	<10	6.7	2200	804	255
RM 186	<20	27.0	0.80	21	400	<10	8.8	4500	0.26	890
RM 188	<20	<0.3	14	23	139	<10	4.6	2.40	<20	<40
RM 190	<20	15.0	160	12	124	<10	5.5	525	95	40
RC 19	<20	0.7	585	11	54	<10	4.4	146	202	50
RC 20	<20	0.4	500	<10	49	<10	2.9	84	203	50
RC 21	<20	0.4	360	12	53	<10	3.5	42	188	66
RC 22	<20	<0.3	268	<10	122	<10	8.2	6.50	<20	<40
RC 23	<20	<0.3	69	13	70	<10	8.2	1.4	<20	300
RC 24	<20	<0.3	54	<10	76	<10	4.8	1.0	<20	<40
RC 25	<20	3.4	0.12	11	112	<10	6.2	1044	308	97
RC 26	<20	<0.3	105	<10	84	<10	7.5	4.8	<20	<40
RC 27	445	<0.3	135	11	87	<10	6.8	1.0	90	66
RV 26	49	<0.3	26	11	84	<10	2.5	512	<20	150

* Copper and antimony values with a decimal point are expressed in per cent. Note that all mercury values in this table are expressed in parts per million.

(Plates 1, 20), is underlain by volcanic tuffs and argillaceous sediments of Unit LK_{TC}. A lobe of granodiorite of the Coast plutonic complex forms the southwestern head of the valley, approximately 500 metres from the mineralization. Distinct orange-weathering zones of rubble and outcrop occur 35 metres apart on either side of the creek and a third isolated zone is exposed 150 metres farther upstream (Figure 27). Quartz-carbonate veining occurs within areas of quartz-ankerite-siderite-kaolinite alteration. Vein breccias contain moderately silicified volcanic fragments as well as banded chalcedonic vein material indicating multiple episodes of brecciation and siliceous healing (Plate 21). Cavities lined with quartz and carbonate crystals are common. Realgar, orpiment and traces of cinnabar occur as fine disseminations, in veinlets, and as crusts on fracture planes in one zone approximately 4.5 metres in true width. Assays of two channel samples across this zone returned an average of 0.2 per cent arsenic and selected samples contain up to 0.4 per cent arsenic; mercury contents range from 6 to 18 ppm and antimony values from 70 to 110 ppm. Precious and base metal values are low in the zone of visible mineralization however 100 to 200 ppb gold are present in samples taken from the other alteration zones. Table 14 lists the geochemical analyses determined on samples from Twin Creek. An anomalous arsenic stream-sediment value was determined in this valley in 1985 (McLaren, 1986b).

Prospecting along the ridge to the west of Twin Creek, near the granodiorite contact, revealed thin rusty fracture zones with quartz-carbonate veining. Pyrite, chalcopyrite, malachite and traces of galena were found in altered and fractured intrusive rocks. Geochemical analyses indicate anomalous gold (up to 2 ppm), silver and arsenic with the copper mineralization (Table 14).

A heavy mineral geochemical survey previously conducted in the area detected highly anomalous lead values in

Plate 20. View of Twin Creek and new mineral showings. The Coast plutonic complex (+) lies to the upper left; the remaining area comprises Unit LK_{TC} volcanics and sediments; Tchaikazan valley in the background.

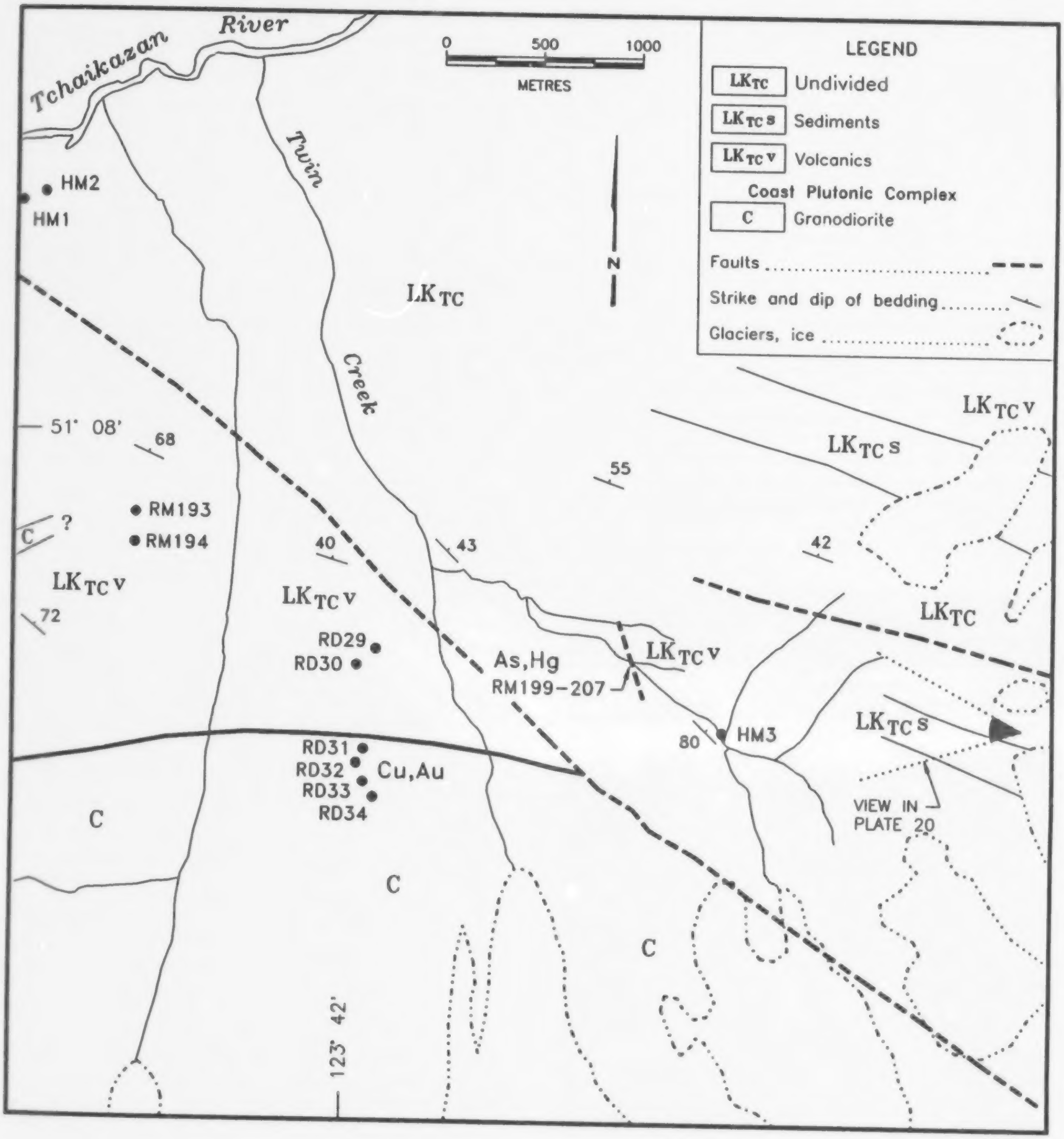

Tchaikazan River
Twin Creek
0 500 1000
METRES
N
LEGEND
LKTC Undivided
LKTC s Sediments
LKTC v Volcanics
Coast Plutonic Complex
C Granodiorite
Faults
Strike and dip of bedding
Glaciers, ice
HM2
HM1
LKTC
51° 08'
68
55
RM193
RM194
C ?
40
43
42
LKTC v
72
LKTC s
RD29
RD30
As,Hg
RM199-207
80
HM3
RD31
RD32
RD33
RD34
Cu,Au
C
VIEW IN PLATE 20
123° 42'

Figure 27. Geological setting of the Twin Creek area.

conjunction with elevated silver values approximately 2 kilometres west of the Twin Creek arsenic showing (Figure 27, Table 14). Prospecting on this slope above the Tchaikazan valley located large rusty hornfels zones and a large dike of granodiorite low on the slope, however, no explanation for the lead anomalies was found. Follow-up exploration by industry here and at the head of Twin Creek valley also failed to detect any mineralization.

Current reconnaissance prospecting along the contact of the Coast plutonic complex near Twin Creek has produced a number of interesting mineral occurrences as well as unexplained geochemical anomalies. The Twin Creek realgar showing has strong promise for further mineralization beneath the glacial drift in the broad, flat valley floor; the alteration zones are known to extend for at least 150 metres. The mineralization and the vein breccia textures are typical of a mesothermal to epithermal environment. Proximity to a granodiorite contact and the presence of a large fault in the valley also fit the model. This fault extends to the southeast toward the Pellaire occurrence and may have influenced the structural preparation for the mineralization there. The presence of gold mineralization 6 kilometres to the southeast, and 6 kilometres to the northeast at the Charlie group, further strengthens the potential of this area to host a precious metal vein system.

Plate 21. Polished surface of silicified, vuggy vein breccia carrying realgar mineralization.

TABLE 14
SELECTED LITHOGEOCHEMICAL ANALYSES FROM THE TWIN CREEK AREA

Sample Number	Au ppb	Ag ppm	Cu* ppm	Pb ppm	Zn ppm	Mo ppm	Fe %	Hg** ppb	Sb ppm	As* ppm
RM 193	<20	<0.3	289	60	144	<10	5.6	<20	<20	<10
RM 194	42	<0.3	24	16	132	<10	3.8	<20	<20	<10
RM 199	<20	<0.3	83	<10	87	<10	5.2	8.5	110	0.42
RM 200	<20	<0.3	99	17	48	<10	6.3	12.1	94	0.36
RM 201	<20	<0.3	79	12	56	<10	6.3	17.6	84	0.40
RM 202	<20	<0.3	58	12	79	<10	5.8	6.6	69	0.24
RM 203	20	<0.3	73	11	99	<10	5.7	8.0	81	0.16
RM 204	101	<0.3	43	11	63	<10	6.4	1.3	<20	72
RM 205	<20	<0.3	46	<10	38	<10	6.9	2.7	<20	97
RM 206	201	<0.3	79	13	96	<10	7.1	3.3	70	290
RM 207	<20	<0.3	74	<10	73	<10	6.0	52	<20	<10
RD 29	<20	<0.3	50	12	58	<10	5.3	727	<20	85
RD 30	<20	<0.3	27	<10	27	<10	5.4	78	<20	55
RD 31	94	2.3	0.45	<10	122	<10	5.1	66	<20	64
RD 32	2020	3.1	0.47	28	138	32	3.1	<20	<20	107
RD 33	315	0.6	3.34	34	404	17	1.0	20	<20	55
RD 34	50	6.4	2.12	107	570	25	1.8	466	32	0.12
HM 1#	80	9.4	600	3400	—	—	—	—	10	35
HM 2#	45	2.0	250	1000	—	—	—	—	5	18
HM 3#	75	2.3	200	1190	—	—	—	—	45	9

* Copper and arsenic values with a decimal point are expressed in per cent.

** Mercury values with a decimal point are expressed in parts per million.

# Heavy mineral analyses from Assessment Report 9023

OTHER VEIN OCCURRENCES

DISCORD CREEK

The western border of the lobe of granodiorite noted in the Twin Creek discussion was also found to be mineralized when a small quartz vein carrying chalcopyrite and molybdenite was discovered in Discord Creek (Plate 1). This branching vein follows a fracture system through both intrusive and volcanic lithologies; the rocks are brecciated and quartz-carbonate or clay alteration is common. Pyritic gossanous material with malachite can be found in the talus below. The vein was traced upslope for over 80 metres and was seen to extend above into steep slopes. Anomalous values in precious metals (up to 499 ppb gold and 99 ppm silver), precious metal indicators (mercury, arsenic, antimony) and base metals (copper, zinc) were determined from this vein system (Table 15). Stream sediment samples collected in this drainage identified anomalies in arsenic and gold (McLaren, 1986c). Lower Discord Creek flows through a deep, fault-controlled canyon cutting through strongly limonitic volcanics. The canyon is relatively inaccessible and was not sampled in this project, however, an anomalous gold value was determined in stream sediments just below this prospective zone. The fault extends upslope into limonitic volcanic rocks to the southeast.

The intrusive rocks extending northwards toward the Tchaikazan valley between Discord and Twin creeks have been mapped by Tipper (1978) as a discrete lobe of Eocene granodiorite. It is apparent from the mineralization and anomalous geochemistry around the entire periphery of this intrusion that hydrothermal fluids enriched in a variety of elements were generated during the intrusive event. The success of the preliminary prospecting conducted to date indicates that further work is necessary to fully evaluate the high mineral potential of this area.

SPECTRUM PEAK AREA

A granodiorite stock cutting sediments and volcanics of Units LK_{TC} and LK_q forms a prominent peak approximately 4 kilometres southwest of Spectrum Peak (Plate 9). Contact metamorphic effects on the sediments and volcanics are minimal. Pyritic quartz-eye tuffs outcrop on the southwest slopes below the peak and anomalous mercury and arsenic analyses were obtained from these rocks. Strongly silicified and quartz-veined volcanic rocks are present in fracture zones adjacent to the intrusion. A talus sample of silicified and quartz veined volcanic material containing sphalerite, galena, chalcopyrite and pyrite, located on the south side of the intrusive stock, returned highly anomalous silver, mercury and antimony analyses in addition to copper, lead and zinc (Table 15). No mineralized bedrock source was located. Even though no extensive indications of mineralization have been found around this peak, the limited prospecting to date has identified vein mineralization with geochmemical anomalies typical of a mesothermal to epithermal system. The rocks in the vicinity are fractured and a large northeast-trending fault passes adjacent to the intrusion. The general environment deserves further prospecting.

TCHAIKAZAN AND STIKELAN FAULT ZONES

Highly anomalous mercury, arsenic and antimony analyses were determined in strongly sheared argillites with quartz-carbonate veins approximately 10 kilometres southwest of the Alexis copper-mercury showing, along the strike of the Tchaikazan fault zone (Table 15). The fault zone is exposed in canyons on lower Tredcroft Creek where a section of volcanic and well-bedded sedimentary rocks is fractured or sheared and intruded by both felsic and mafic dikes. Clay gouge and graphitic zones have developed in black argillaceous sediments; chloritic alteration is more common in the volcanics. Localized pyritic sections are present, usually in association with quartz-carbonate veins. These features indicate that the mineralization that occurs at Alexis may recur anywhere along this section of the Tchaikazan fault zone.

Similar environments are present in the fault zone south of Yohetta Lake where a diorite stock outcrops at the intersection of a structure paralleling the Tchaikazan fault and a northeast-trending fault (Figure 5). Traces of copper mineralization have been found in a silicified segment of the fault immediately east of this intrusion. Copper, mercury and arsenic anomalies were detected in rock samples in this area (Figure 20). North of Yohetta Lake similar anomalies are present in a similar geologic environment. The Stikelan fault zone represents an equally prospective environment at the head of Girdwood Creek where anomalous levels of silver, copper, mercury and arsenic were detected in altered or veined sections of the zone (Figure 20). Southeast of Franklyn Arm a prominent northerly trending, brown, carbonate alteration zone above the shore of Chilko Lake returned one analysis anomalous in arsenic (0.2 per cent) and mercury (2.2 ppm) (Figure 20). Even though no obvious fault was seen here, air photo linears and faults were noted to the south along strike from this alteration zone.

GIRDWOOD LAKE

Traces of copper mineralization are present in talus north and south of Girdwood Lake. Prospecting upslope revealed epidote-alteration zones containing quartz-carbonate veins and vein-breccias carrying native copper, tetrahedrite and malachite. Prehnite is a common accessory mineral in vuggy cavities in the veins. Analyses of this material show anomalous levels of silver and mercury in addition to copper (Table 15). Quartz-epidote veining, common over a broad area underlain by fractured volcanics of Unit LK_{pv}, is similar to the veining in the vicinity of the Charlie group.

UPPER TASEKO LAKE

Prominent brown, carbonate alteration zones are visible on the ridge crest immediately west of Upper Taseko Lake, 4 kilometres east of the Charlie group. Carbonate veining and breccia zones with minor silicification outcrop discontinuously along a 300-metre zone trending northwesterly through volcanics of Unit LK_{TC}. Pyrite and traces of tetrahedrite are the only sulphide minerals noted. Analyses of four rock-chip samples from this area revealed only a single anomaly in arsenic (Table 15). Previous reconnaissance exploration indicated anomalous copper, lead and zinc values (Assessment Report 10774) and anomalous levels of arsenic, mercury, lead and zinc were determined in stream sediments by the Regional Geochemical Survey in this area (British Columbia Ministry of Energy, Mines and Petroleum Resources, 1979).

PORPHYRY COPPER DEPOSIT ENVIRONMENTS

CHARLIE AREA (MINFILE 92O 043)
LOWER TCHAIKAZAN VALLEY

Following the discovery of the precious metal veins on the Charlie group, further exploration in the surrounding area revealed copper and molybdenum mineralization as disseminations and in veins in fractured volcanic and intrusive rocks along the banks of the Tchaikazan River. During the 1950s and 1960s a number of companies conducted a limited amount of geochemical and geophysical prospecting; eight diamond-drill holes totalling 380 metres were completed in 1967 with inconclusive results. A number of two-post mineral claims were staked in the valley floor, adjoining the Crown grants of the Charlie group, to cover this broader zone of mineralization.

In the early 1970s a soil geochemical survey identified a zone of coincident copper-molybdenum anomalies just north of the Tchaikazan River (Assessment Report 3131); induced polarization and magnetometer surveys identified specific zones of increased chargeability and magnetic response, some of which were coincident with the geochemical anomalies (Asssessment Report 3507). Some 460 metres of diamond drilling in seven holes failed to intersect sufficient mineralization to justify continuation of the program.

In 1981 Suncor Incorporated acquired the property and undertook considerable staking of surrounding ground to protect its interest while exploring a broad area for porphyry copper mineralization. The precious metal veins were not explored in detail as they were thought of only as indications

TABLE 15
SELECTED GEOCHEMICAL ANALYSES FROM OTHER VEIN OCCURRENCES

Sample Number	Au ppb	Ag ppm	Cu* ppm	Pb* ppm	Zn* ppm	Mo ppm	Fe %	Hg** ppb	Sb ppm	As* ppm
Discord Creek										
RC 28	<20	0.8	0.22	<10	49	<10	1.5	328	<30	<20
RC 29	499	99	4.5	26	0.16	126	13.7	1.2	<30	260
RC 34	34	3.6	900	40	80	<10	1.6	469	<30	<20
RC 35	86	54	1.68	460	937	17	4.8	8.8	440	0.27
RC 36	266	37	1.48	56	860	18	5.4	7.8	<30	0.18
Spectrum Peak Area										
RM 45	<20	<0.3	20	<10	95	<10	2.6	635	<30	49
RM 46	<20	<0.3	33	10	100	<10	6.71	3.8	<30	255
RB 15	154	138	355	4.1	10.1	38	1.8	>10.0	256	<20
RB 16	<20	10	98	33	170	<10	2.8	900	<30	<20
RB 17	<20	7	7	13	37	<10	2.9	3.4	<30	<20
Tchaikazan Fault Zone — Tredcroft Creek										
RM 121	<20	<0.3	93	18	124	<10	4.1	75.0	109	1.0
Stikelan Fault Zone — Girdwood/Tredcroft Creeks										
RM 156	<20	<0.3	0.11	<10	52	<10	11.2	870	<30	<20
RM 166	<20	<0.3	26	26	93	<10	4.5	1.6	<30	<20
RV 20	<20	7.5	1.1	<10	70	<10	4.3	157	<30	<20
Girdwood Lake										
RC 11	21	3.4	0.54	<10	11	<10	2.1	665	121	<20
RC 12	<20	7.5	1.49	10	19	<10	5.3	2.1	67	<20
RD 11	<20	4.3	0.77	<10	32	<10	5.4	1.0	<30	<20
RM 167	<20	0.9	0.22	10	26	<10	1.5	57	<30	<20
RM 168	<20	2.0	0.65	14	65	<10	5.0	560	<30	<20
Upper Taseko Lake										
RM 317	<20	<0.3	14	<10	38	<10	2.3	1.7	19	254

* All copper, zinc, lead and arsenic values with a decimal point are expressed in per cent.

** All mercury values with a decimal point are expressed in parts per million.

of a porphyry system. Geological mapping, geochemical and geophysical surveying, and prospecting in the following years confirmed the previous surface results in the valley floor adjacent to the copper-molybdenum mineralization. New areas of veinlet copper-silver mineralization were identified over a broad area of fractured volcanics up to 6 kilometres to the north and northwest of the previously known mineralization (Figure 25; Assessment Reports 10330, 10774, 12105, 12106). Geophysical responses typical of disseminated mineralization related to porphyry systems were also identified. Petrographic work identified several alteration assemblages, including the potassic, phyllic and propylitic alterations common to porphyry systems.

The area is underlain primarily by volcanic flows and pyroclastics of Unit LK_{TC}; minor interbedded sedimentary horizons are also present. Major northwest-trending faults separate these rocks from the purple volcanic lithologies of Unit LK_{pv} to the north. A thin wedge of fossiliferous sediments of Unit LK_{RM} outcrops immediately north of the Charlie group veins. Stocks and dikes of granodiorite, diorite and quartz feldspar porphyry cut all the volcanic units; based on geophysical interpretations the intrusives may be more extensive beneath the Tchaikazan valley.

A network of quartz veinlets carrying chalcopyrite and molybdenite mineralization is evident in outcrops along the banks of the Tchaikazan River where granodiorite dikes cut the volcanics; widespread fracturing, clay gouge zones and argillic alteration are common in all lithologies. Rock-chip sampling in this area in 1981 returned copper values in the 0.04 to 0.21 per cent range and molybdenum values of 0.01 to 0.02 per cent; silver values were erratic between 0.7 and 38 grams per tonne and gold was reported as trace (Assessment Report 10330). Four mineralized samples collected in this project returned up to 0.58 per cent copper and 0.12 per cent molybdenum (Table 11).

Exploration to date has identified many of the criteria of the porphyry copper deposit model. The intrusives provided the heat source for fluid convection, the rocks are well fractured to provide channelways for fluid movement, disseminated and veinlet copper and molybdenum mineralization is present deep in the system and precious metal and copper-bearing veins occur at higher levels on the periphery. These characteristics fit the British Columbia epithermal model and illustrate the potential for both porphyry deposits and precious metal veins. The nearby Fish Lake deposit and Chita occurrence share a similar setting; the gold content of the Fish Lake deposit is of continuing interest to companies working in this area. Although exploration on this property has not identified a mineral resource, the delineation of a large low-grade porphyry copper-gold deposit analogous to the Fish Lake mineralization remains a possibility. If such a deposit contains significant amounts of recoverable gold, it would offer potential for mine developmemt.

TARN CREEK

A previously undocumented zone of stockwork copper mineralization was discovered during this project approximately 4 kilometres north-northeast of the west end of Yohetta Lake (Figure 5). The valley at this location is referred to as Tarn Creek (McLaren, 1986a). The area is largely underlain by volcanic lithologies of Unit UK_v, dominated by feldspar hornblende porphyry flows and associated volcanic lithic fragmental rocks. A variety of dikes and irregularly shaped bodies of hornblende diorite porphyry intrude the volcanics on both sides of the valley (Figure 28). Compositional similarities and field relationships suggest many of these are subvolcanic in origin. Quartz and/or carbonate alteration zones are common adjacent to the intrusions.

A tributary creek on the east side of the valley cuts through a large zone of well-fractured and altered volcanics and intrusive rocks. Propylitic alteration in the volcanics has produced carbonates, epidote and chlorite as complete replacements of, or irregular halos around, feldspar and hornblende phenocrysts. Argillic alteration or silicification are locally present. A discontinuously exposed gossanous zone, covering an area of approximately 400 by 150 metres, surrounds a strongly developed quartz stockwork zone (Plate 22). Within this zone chalcopyrite, bornite, pyrrhotite and pyrite mineralization occurs in veinlets, as fracture coatings and as disseminations throughout all rock types. Magnetite and chlorite are common accessory minerals. Selected rock-chip samples from this zone returned copper analyses from 200 to 5000 ppm, some with anomalous silver values. Rock-chip sample locations in this valley are shown in Figure 28 and analytical results presented in Table 16. Anomalous copper and molybdenum values occur in the stream sediments below this mineralization. Cobbles in till in Tarn Creek valley contain disseminated copper mineralization; a single cobble of massive epidote cut by quartz-calcite-chalcopyrite veinlets has been found. Skarn mineralization, including hematite, epidote, andradite garnet, calcite, quartz and minor chalcopyrite, has developed in localized pockets of calcareous tuffs adjacent to intrusive contacts at the head of the valley.

The valley follows the trace of a major northeast-trending fault. Prominent fractures in the headwall of the valley and silicified and carbonate-altered fault breccias mark the location of the fault zone. The northwest-trending Tchaikazan fault zone intersects the northeast-trending fault approximately 2 kilometres south of the stockwork copper zone. A subsidiary fault cuts through the stockwork zone. This structural setting is distinctly similar to those documented at both the Fish Lake and Poison Mountain deposits.

The head of this valley is interpreted as being the roof zone of a porphyry system as characterized by the swarm of intrusive dikes and small irregular stocks, the thoroughly fractured and altered rocks, the quartz stockwork system and the widespread mineralization. Multiple phases of intrusive dikes and quartz veinlets are indicated by crosscutting relationships. The nearby intersection of major regional faults may have influenced emplacement of a large intrusive body at depth. The similarities between this occurrence and the Fish Lake and Poison Mountain deposits suggest a significant untested potential exists at Tarn Creek.

The hazardous steep slopes and thoroughly fractured rock surrounding the stockwork zone made sampling difficult; pending a more complete evaluation of this valley its mineral potential must be considered high.

MOUNT GODDARD

Disseminated and veinlet copper mineralization are exposed adjacent to a hornblende diorite intrusion in an area of complex faulting at the base of Mount Goddard. Volcanic flows and tuffs of Unit LK_v have been thrust over interbedded sediments and volcanics of Unit LK_{TC} (Plate 14). A hornblende diorite stock and related dikes cut both rock units and appear to cut the thrust. Northwest-trending faults also cut across all lithologies (Figure 29). Propylitic alteration is widespread in the volcanics of Unit LK_v. Argillic alteration and intense silicification occur locally in the fault zones. Prominent limonitic zones have developed over the fault zones and adjacent to the intrusions. A limited amount of exploration work was conducted on this site in 1983 (Assessment Report 12107).

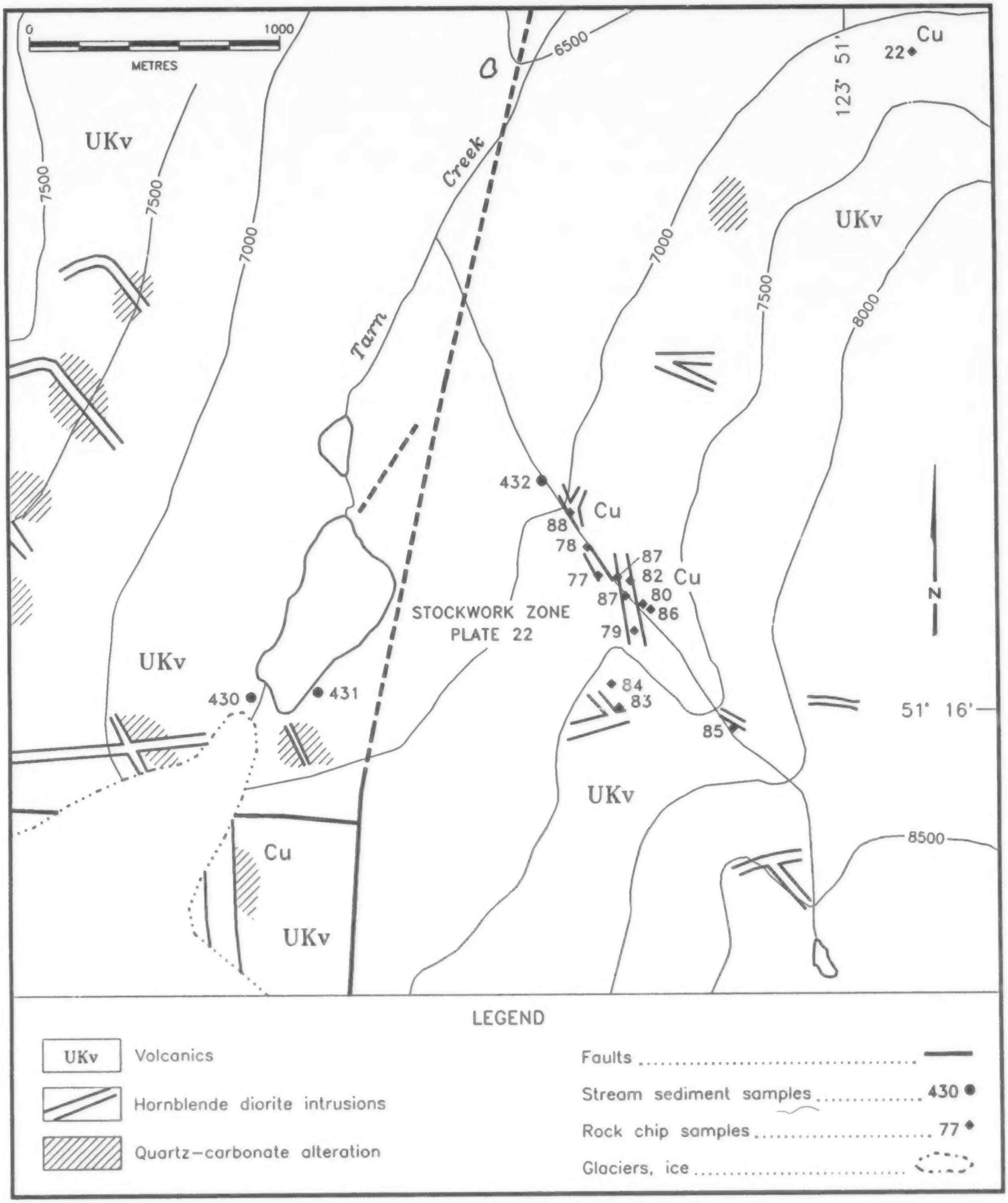
Two styles of mineralization are present at Mount Goddard; disseminated copper mineralization in fractures and quartz veinlets related to the porphyritic intrusive, and pyrite-pyrrhotite mineralization in the fault zones. Immediately west of a small tarn below the summit of Mount Goddard, chalcopyrite, malachite and azurite are disseminated in the diorite intrusion and in quartz veinlets cutting it. The highest copper values determined, up to 1.76 per cent in a selected sample, came from this area. Samples also contain anomalous silver (9 ppm), molybdenum (30 ppm) and mercury (3.4 ppm). Previous sampling here returned similar copper values (up to 1.92 per cent; Assessment Report 12107). The pyrite-pyrrhotite zones in fault zones may be hornfels alteration related to the nearby intrusions. No significant lithogeochemical anomalies were identified except for an isolated arsenic value (150 ppm).

Anomalous copper in stream sediments clearly identifies the Mount Goddard mineralization. Scattered lithogeochemical anomalies in arsenic and mercury in the area between Mount Goddard and Mount Kern may be related to fluid movement through fault zones.

The potential for economic mineralization between Mount Goddard and Mount Kern is rated moderate. There is evidence of hydrothermal activity related to the intrusive bodies, however, only a limited number of supporting criteria for an epithermal or porphyry metallogenic model have been documented.

OTHER PORPHYRY OCCURRENCES

This project documented a number of other mineral occurrences with features suggestive of a porphyry environment.


0
1000
METRES
UKv
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82 Cu
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79
STOCKWORK ZONE
PLATE 22
UKv
430
431
84
83
85
51° 16'
N
UKv
Cu
UKv
8500
LEGEND
UKv Volcanics
Hornblende diorite intrusions
Quartz–carbonate alteration
Faults
Stream sediment samples 430 ●
Rock chip samples 77 ◆
Glaciers, ice

Figure 28. Geological setting of the Tarn Creek area.

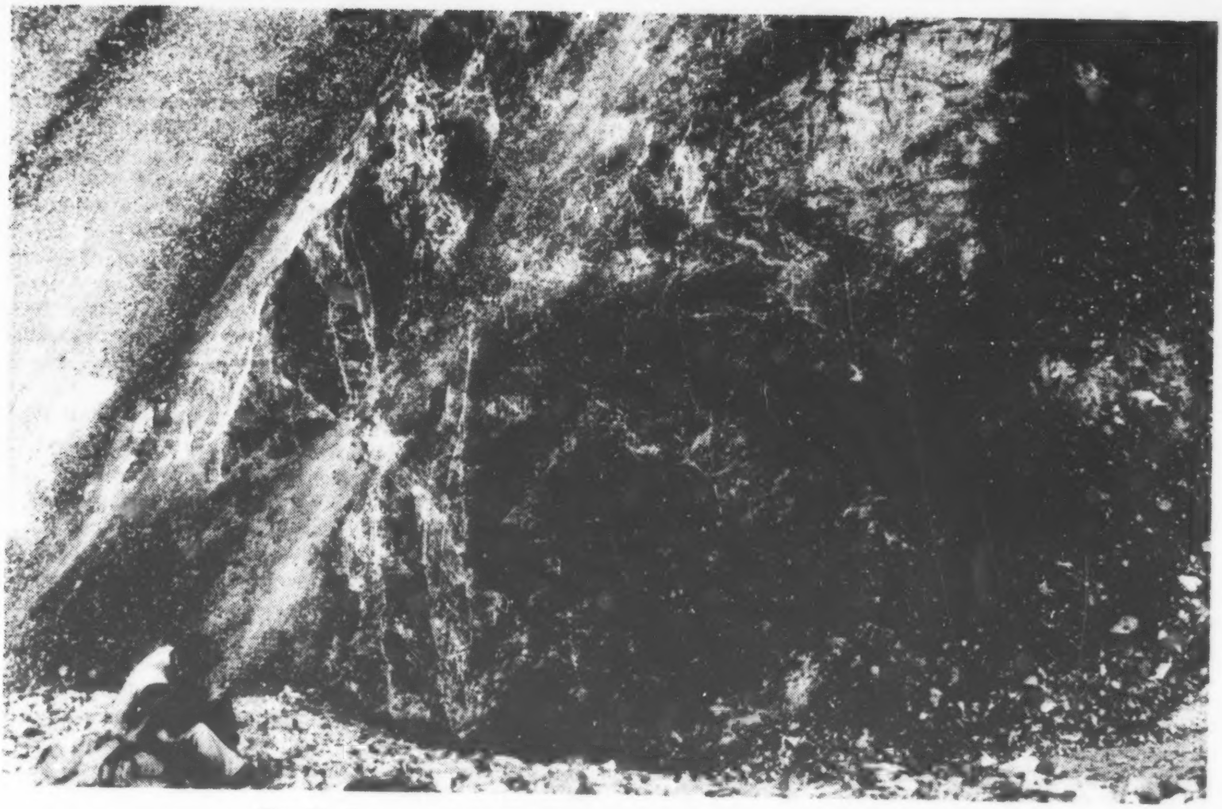

Plate 22. Copper-bearing quartz-stockwork zone, Tarn Creek copper occurrence.

TABLE 16
SELECTED GEOCHEMICAL ANALYSES FROM THE TARN CREEK COPPER OCCURRENCE

Lithogeochemistry

Sample Number	Au ppb	Ag ppm	Cu* ppm	Pb ppm	Zn ppm	Mo ppm	Fe %	Hg** ppb	Sb ppm
RM 73	<20	<0.3	35	<10	80	<10	3.37	6.1	<20
RM 74	<20	<0.3	33	<10	79	<10	3.76	1.0	<20
RM 75	<20	<0.3	152	<10	112	11	10.2	440	<20
RM 76	<20	<0.3	219	<10	92	<10	3.82	215	<20
RM 77	<20	0.4	255	<10	33	10	4.63	130	<20
RM 78	<20	0.3	300	<10	29	<10	4.06	402	<20
RM 79	<20	<0.3	420	<10	38	<10	8.15	138	<20
RM 80	<20	1.0	0.12	<10	39	<10	7.85	138	<20
RM 81	<20	0.4	940	<10	36	52	3.31	152	<20
RM 82	<20	0.4	0.11	<10	39	<10	5.52	215	<20
RM 83	<20	<0.3	343	<10	18	14	6.64	55	<20
RM 84	44	3.0	0.48	<10	57	<10	4.48	115	20
RM 85	<20	0.3	313	<10	63	<10	6.61	25	<20
RM 86	<20	<0.3	210	<10	34	24	6.06	82	<20
RM 87	<20	<0.3	207	<10	36	42	6.31	55	<20
RM 88	<20	1.5	362	<10	34	<10	4.12	1.4	35
RB 19	<20	3	16	89	12	<10	3.31	300	<20
RB 20	<20	2	16	12	154	<10	4.00	650	<20
RB 21	<20	<0.3	46	<10	50	<10	3.45	510	<20
RB 22	<20	<0.3	91	11	86	12	14.1	1.7	<20

* All copper analyses with a decimal point are expressed in per cent.

** All mercury analyses with a decimal point are expressed in parts per million.

Stream Sediment Geochemistry

Sample Number	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Mo ppm	Mn ppm	Fe %	Hg ppb	Sb ppm	Ba ppm
430	<1	0.2	46	<2	60	16	26	<1	650	5.45	80	20	60
431	8	0.2	82	<2	310	22	32	<1	1202	5.10	310	20	110
432	11	0.8	782	<2	170	43	24	18	601	6.21	170	30	50

Most are small, isolated occurrences, poorly known at present, that may be indicators of more significant mineralization.

Disseminated copper mineralization was discovered in a quartz diorite stock cutting Triassic sediments and volcanics of Unit $UT_{v,s}$ at the head of Tredcroft Creek. Talus of a slightly more mafic phase on the south side of the intrusion contains disseminated pyrite, chalcocite and tetrahedrite. Analyses of two samples of this material returned anomalously high levels of silver, copper, lead, zinc and molybdenum. The source of this material is presumed to be on the steep bluff at the southern edge of the stock. Alteration of the intrusion and surrounding volcanics is minimal; some chlorite and sericite alteration and a few quartz-epidote veins are present. The eastern side of the intrusion is cut by a number of faults and the enclosing sediments and volcanics here contain weakly altered limonitic zones but no anomalous geochemistry was detected.

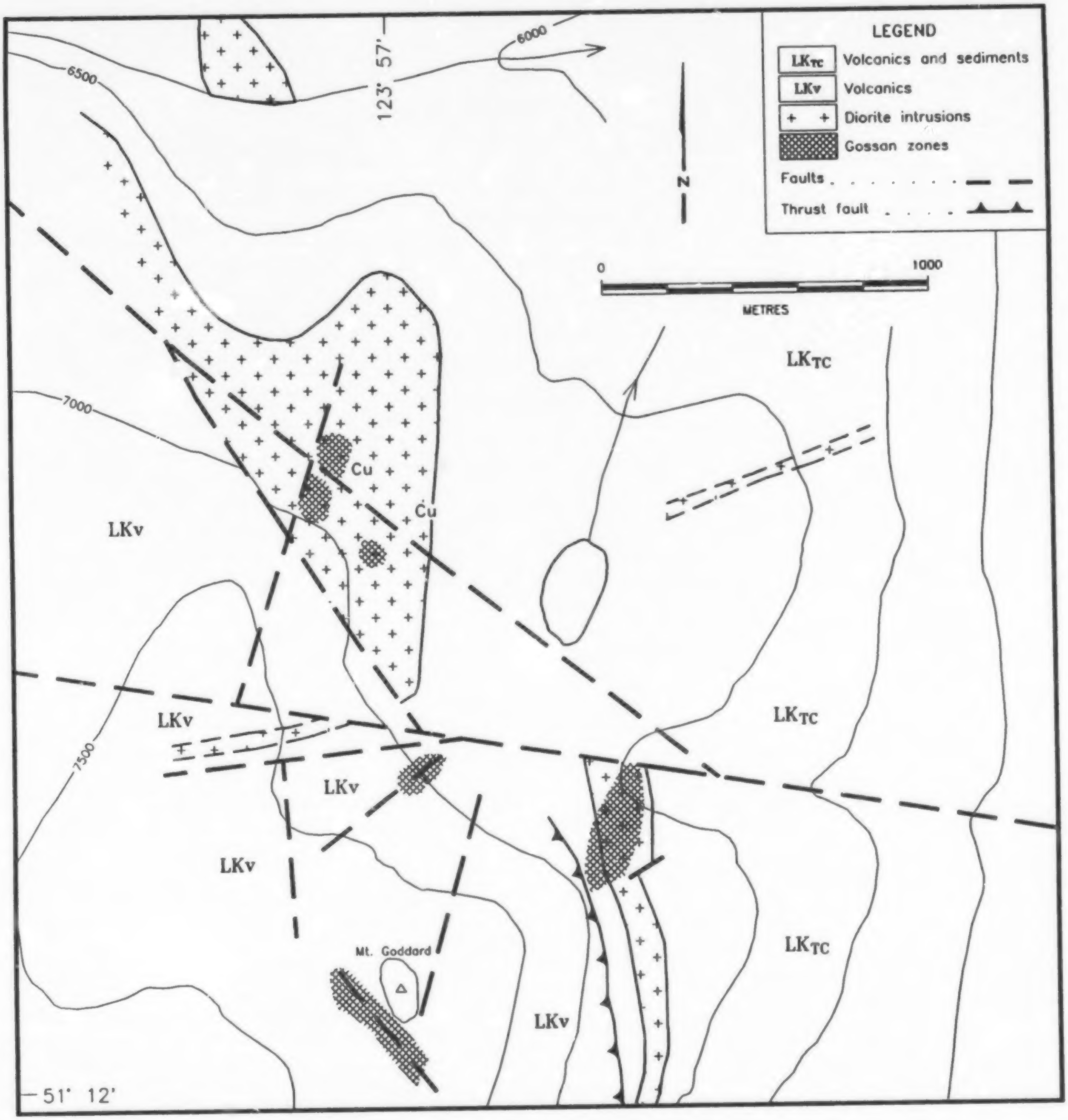
LEGEND
LKTC Volcanics and sediments
LKv Volcanics
Diorite intrusions
Gossan zones
Faults
Thrust fault
0
1000
METRES
N
6000
6500
7000
7500
123° 57'
51° 12'
Cu
Cu
LKv
LKv
LKv
LKv
LKv
LKTC
LKTC
LKTC
Mt. Goddard

Figure 29. Geological setting of the Mount Goddard area.

Exploration in this area has located similar mineralization along the northwestern contact of the intrusion on a ridge overlooking Tredcroft Glacier (MINFILE 92N 008, 9; Assessment Report 2671). Chalcopyrite and minor molybdenite are reported in closely spaced parallel fractures or as disseminations in the quartz diorite. Copper values up to 0.86 per cent have been determined; precious metal values are not significant. Further to the south, at the head of Austen Glacier, fractured and hornfelsed volcanic rocks of Unit LK_V are cut by a branching quartz vein carrying chalcopyrite and molybdenite. Mafic dikes roughly parallel the fracture system. A grab sample of this mineralization assayed 1.8 per cent copper, 0.17 per cent molybdenum, 14 grams per tonne silver and 0.30 gram per tonne gold. Tipper (1969) records a minor molybdenum showing in quartz veins adjacent to a granodiorite stock west of Stikelan Creek, approximately 10 kilometres northwest of the head of Tredcroft Creek.

South of Franklyn Arm, quartz fissure-vein systems carrying molybdenite and chalcopyrite have been recorded within another granodiorite stock (MINFILE 92N 014, 15; Assessment Report 8295). Considerable rock-chip sampling was conducted by industry near the gossan surrounding the mineralization. The veining was not sufficiently extensive to encourage follow-up work after the initial discovery. Precious metal values are also reported to be low. This stock is immediately east of the Daisie skarn mineralization in Deschamps valley (Figure 5).

As previously discussed in Chapter 2, the line of satellite stocks paralleling the contact of the Coast plutonic complex west of Chilko Lake and the extensive hornfelsing of the country rocks suggest intrusive rocks may underlie much of the area. This may be responsible for the widespread indications of porphyry style mineralization through this belt. Reconnaissance rock-chip sampling of a number of limonitic zones between Franklyn Arm and Chilko Lake (Assessment Report 8295) did not reveal any significant geochemical anomalies in copper, molybdenum, gold, silver or tungsten.

SKARN ENVIRONMENTS

DAISIE COPPER-TUNGSTEN SHOWING
(MINFILE 92N 026)
FRANKLYN ARM AREA

Copper-bearing skarn mineralization has been known on the Daisie property near the head of Franklyn Arm since the early 1920s. Dolmage (1925) briefly described the property and recognized the economic potential along the intrusive contacts. The property received limited attention in the 1950s and 1960s but was explored more extensively in the 1970s. A number of small trenches and pits expose sections of marble containing variable amounts of chalcopyrite, pyrrhotite, molybdenite and scheelite. Twelve hundred metres of diamond drilling was completed in 31 holes between 1978 and 1980. (Assessment Reports 7156, 7574, 8682). Long intersections of low-grade copper (*e.g.*, 0.19 per cent over 18 metres), molybdenum (*e.g.*, 0.32 per cent over 15 metres) and tungsten (0.30 per cent over 55 metres) mineralization have been reported, however, the distribution of mineralization within these intersections is not clear. Any precious metal values reported are low. The Daisie property was included in a large claim block surrounding the intrusive stocks south of Franklyn Arm that was evaluated in 1980 (Assessment Report 8295; *see* Figure 11).

The mineral showings are hosted by the Triassic metasedimentary and metavolcanic assemblage of Unit $UT_{v,s}$ that is partially exposed as an uplifted fault block within Deschamps valley (Figure 5). Argillaceous to arkosic clastic sediments and limestones are interbedded with intermediate to basic volcanic tuffs and flows. These rocks have been intruded by stocks and dikes ranging from diorite to granodiorite in composition. A fine-grained, altered diorite to quartz diorite truncates the stratified sequence in Deschamps valley while a much fresher and coarser quartz diorite to granodiorite stock outcrops over a much larger area on the mountains to the east. A dike of the fresher material cuts the finer, altered intrusive. Diamond drilling suggests that intrusive rocks may lie at relatively shallow depths beneath portions of Deschamps valley. The stratified rocks have been hornfelsed to an extent that fine tuffs and sediments are difficult to distinguish. Biotite is a common alteration product. Disseminated pyrite and pyrrhotite are often found in a siliceous or sericitic matrix. The limestones have been converted to a massive, white to grey, sucrosic marble with streaks of biotite providing some indications of relict bedding. Previous mapping and drilling indicate the marble attains a thickness in excess of 100 metres; although this is not evident from sparse outcrop in the drift-covered valley.

Mineralization exposed in the trenches is related to layering or fracture zones within the marble and often occurs as near massive sulphide pods. Prominent, limonitic fracture zones contain thin streaks of pyrrhotite and chalcopyrite in sharp contact with marble, or strongly silicified zones containing veinlets or closely spaced stringers of chalcopyrite and pyrrhotite. Sphalerite, pyrite, molybdenite and specks of scheelite are common throughout. Skarn minerals identified include epidote, clinozoisite, grossularite to andradite garnet, diopside, wollastonite, actinolite, calcite and chlorite, together with minor apatite and sphene. Quartz and skarn assemblage veins cut most lithologies. Four samples representing both massive sulphide and calcsilicate skarn mineralization were collected from the trenches; geochemical analyses from these samples are shown in Table 17. Anomalous levels of copper, zinc, molybdenum and silver are evident. These particular samples were also analyzed for tungsten, chromium and strontium. Tungsten ranged from 100 ppm to 0.5 per cent; chromium and strontium are not anomalous.

TABLE 17
SELECTED GEOCHEMICAL ANALYSES FROM THE DAISIE SKARN OCCURRENCE

Sample Number	Au ppb	Ag ppm	Cu %	Pb ppm	Zn ppm	Co ppm	Ni ppm	Mo ppm	Fe %	Hg ppb	W* ppm
RM 100	162	80	5.1	<10	7600	240	212	22	36.6	257	100
RM 104	67	33	2.0	13	1900	50	39	460	11.4	129	430
RM 105	63	60	4.0	<10	2300	42	30	162	12.6	188	0.5
RM 106	46	30	1.7	<10	1400	40	42	<10	11.4	114	0.1

* All tungsten analyses with a decimal point are expressed in per cent.

A cliff on the east side of Deschamps valley exposes marble bands within layered metasediments and metavolcanics. Skarn zones are irregularly developed within the marble and appear to be controlled by bedding planes. Hydrothermal fluids from the adjacent stock may have been channeled along bedding planes or along the contact between volcanic dikes and marble (Assessment Report 8295). Porphyry-style mineralization previously noted in this stock further attests to the hydrothermal solutions active in this area.

The only lithology with sufficient calcareous units to have potential for skarn development is the Triassic sequence west of Chilko Lake. This unit outcrops in two areas, both of which appear to be exposed through uplift related to satellite intrusions of the Coast plutonic complex; predictably, many of the criteria for a skarn deposit model are present. The intrusive stocks provide ample evidence of a mineralizing hydrothermal environment and the faulted calcareous strata have the required channelways and host rocks for skarn development. Copper, molybdenum and tungsten mineralization has been documented in sufficient extent to warrant further investigation; recommended follow-up work from the last period of exploration has never been done. Further potential for skarn mineralization exists beneath the glacial drift elsewhere in Deschamps valley and possibly in the Triassic rocks at the head of Tredcroft Creek, however, systematic prospecting for further marble exposures or for this style of mineralization has not been conducted.

VOLCANOGENIC MASSIVE SULPHIDE ENVIRONMENTS

Geological mapping of the Chilko Lake Planning Area has documented environments favourable for the formation of volcanogenic massive sulphide deposits and has allowed correlations with similar environments containing significant mineralization. Within the favourable environments in the map area, mineralization currently documented is mainly limited to iron sulphides with anomalous levels of base metals and silver; these environments are discussed below.

Prominent gossan zones are evident on a ridge crest 7 kilometres south of Mount Goddard and to the west of this point on the shores of Chilko Lake. In both localities rhyolitic volcanic rocks of Unit LK_V host disseminated and veinlet pyrite-pyrrhotite mineralization. On the shore of Chilko Lake quartz-eye volcanic lithologies vary from fine-grained tuffs to coarser lithic fragmental and brecciated material containing 5 to 7 per cent sulphides. Three kilometres along strike to the southeast, along the ridge crest, pyrite-pyrrhotite gossan is hosted by fine cherty material contained within a layered sequence of quartz feldspar tuffs. Siliceous volcanic rocks with disseminated pyrite extend a further 3 kilometres to the east. These occurrences represent a period of island arc felsic volcanism and associated iron-rich hydrothermal activity, however base and precious metal analyes have not provided any evidence of polymetallic massive sulphide mineralization. These volcanics lie adjacent to the Coast plutonic complex contact, however, the gossanous zones are distinctly different in texture, colour and geochemistry from the broad, siliceous hornfels zones typical of this intrusive contact aureole.

Immediately north of Franklyn Arm bedded quartz feldspar volcanic tuffs and breccias are associated with more massive quartz-feldspar porphyries of possible subvolcanic origin. On the ridge crest rhyolitic tuffs with cherty horizons are interbedded with epiclastic sediments including quartz-rich greywacke and cherty conglomerate. Spherulitic textures are apparent in some of the fine-grained siliceous volcanics. Pyrite and pyrrhotite occur within gossanous zones as disseminations, along fractures, and as massive pods (MINFILE 92N 016); minor malachite is also present. Anomalous levels of silver, copper, lead, zinc and iron were determined in four samples collected from the mineralized zones; analyses are presented in Table 18. Further to the east along this ridge, sections of felsic tuffs and epiclastics with gossanous alteration are repeated. In one location, flow-banded rhyolites are present but no mineralization was noted. Isolated arsenic and silver anomalies were determined within the gossanous sections.

TABLE 18
SELECTED GEOCHEMICAL ANALYSES FROM THE FRANKLYN ARM AREA

Sample Number	Au ppb	Ag ppm	Cu* ppm	Pb ppm	Zn ppm	Mo ppm	Mn* ppm	Fe %	Hg ppb	Sb ppm	As ppm
RM 169	<20	<0.3	0.29	11	73	<10	715	13.0	42	<20	<40
RM 170	129	5.0	0.30	13	75	<10	655	20.6	109	<20	40
RM 171	<20	1.0	0.17	13	770	<10	0.36	20.5	755	<20	69
RM 172	<20	<0.3	52	144	168	<10	0.10	2.7	133	50	343

* Copper and manganese values with a decimal point are expressed in per cent.

Elsewhere, felsic volcanic horizons with minor disseminated pyrite exist within Unit LK_{TC} strata. At one location in the lower Tchiakazan valley, jasperoidal breccia in a felsic volcanic was found in talus while prospecting gossan zones in the vicinity of a stream-sediment arsenic anomaly. One gossan sample is anomalous in arsenic (222 ppm); the source of the jasperoidal breccia was not located. Seven kilometres to the west, in the Tchaikazan valley, felsic volcanics cut by a fault zone carry pyrite and pyrrhotite and returned anomalous silver, lead and zinc values (23, 114 and 616 ppm respectively).

Favourable environments for volcanogenic massive sulphide deposits are well documented in the Chilko Lake Planning Area, however, only iron sulphide gossans have been found to date. Further exploration of the Lower Cretaceous volcanic island arc environments on the east side of the Coast plutonic complex may ultimately discover this style of mineralization.

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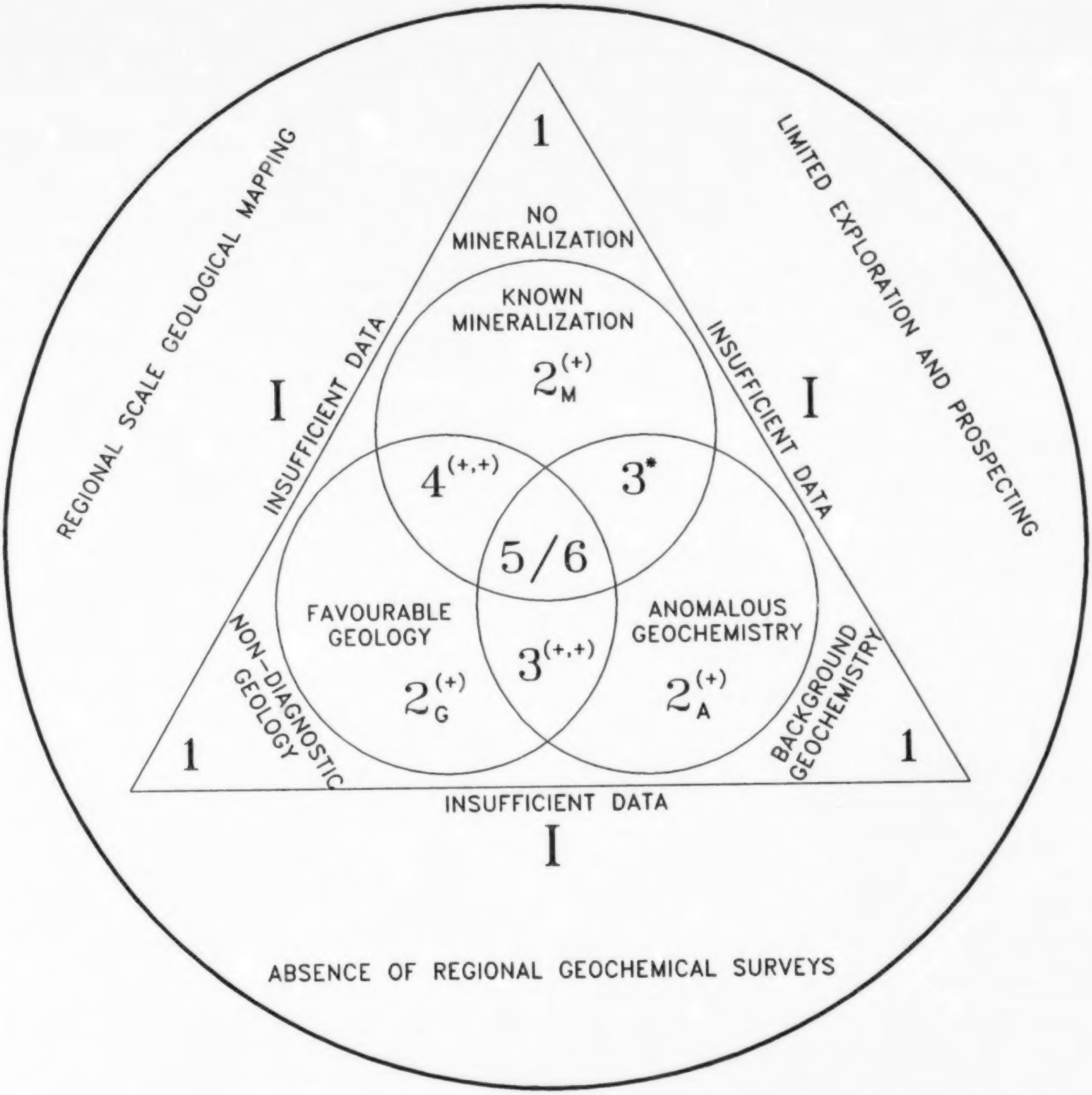


REGIONAL SCALE GEOLOGICAL MAPPING
LIMITED EXPLORATION AND PROSPECTING
ABSENCE OF REGIONAL GEOCHEMICAL SURVEYS
1
NO MINERALIZATION
KNOWN MINERALIZATION
$2_M^{(+)}$
INSUFFICIENT DATA
I
INSUFFICIENT DATA
I
$4^{(+,+)}$
3^*
5/6
FAVOURABLE GEOLOGY
ANOMALOUS GEOCHEMISTRY
$3^{(+,+)}$
$2_G^{(+)}$
$2_A^{(+)}$
NON-DIAGNOSTIC GEOLOGY
BACKGROUND GEOCHEMISTRY
1
1
INSUFFICIENT DATA
I

Figure 30. Diagrammatic Classification of Mineral Potential. The classification is based on two factors, "favourability" and "degree of confidence", applied to the three types of data accumulated in the study. "Favourability" is related to satisfying criteria for a metallogenic model while a greater "degree of confidence" is achieved when favourable elements from each type of data overlap and indicate higher mineral potential. Plus signs (+) are used to indicate localized areas of particularly favourable data. Subscripts in Class 2 designations define the single type of favourable data.

CHAPTER 5

MINERAL POTENTIAL

INTRODUCTION

Mineral potential was previously defined in Chapter 1 as the characteristic attributed to a geologic domain that describes the probability of occurrences of mineral resources or reserves. It was stressed that mineral potential and the definition of resources or reserves are flexible concepts influenced by changing geologic thought, economics, technology and local infrastructure. The discussion of mineral potential in this chapter considers only geological factors in demonstrating first; the favourable mineral potential of the Chilko–Taseko Lakes area considered as a whole; and second, the relative potential of various zones within the Chilko Lake Planning Area. The intent is to demonstrate that the planning area lies on a regional trend of high mineral potential and to then identify zones within the area thought most likely to contain a mineral resource. A classification of mineral potential has been developed to identify areas of higher or lower perceived mineral potential. Three studies, briefly discussed below, form the basis of the classification.

Voelker *et al.* (1979) have used a dual rating system to determine the relative mineral potential of numerous small wilderness proposal tracts within large metallogenic belts. For each wilderness tract they determined the "favourability" (*i.e.*, the potential of a particular environment to contain resources) and the "certainty" (based on the presence or absence of known resources) for the occurrence of mineral resources. These factors were then combined with other criteria into an overall importance rating illustrating mineral potential. The system was indicated to be sensitive in identifying anomalous tracts and was efficient and consistent for making resource management decisions.

The Conterminous United States Mineral Assessment Program (CUSMAP) provides regional mineral assessment information for policy development and land-use decisions while simultaneously providing a range of geological data of use in mineral exploration. Two studies recently published under this program (Gair *et al.*, 1986; Harrison *et al.*, 1986) illustrate the value of rating the "favourability" of various types of diagnostic data to give indications of mineral potential and of assigning a higher "degree of confidence" to those areas with multiple types of supporting data.

MINERAL POTENTIAL CLASSIFICATION SYSTEM

The mineral potential classification scheme used here is focused on identifying the relative potential of different zones within the Chilko Lake Planning Area to contain a mineral resource that could conceivably be mined at present or in the future. The existence of, or potential for, such a resource is the primary information required for the land-management decisions that must ultimately be made. Within the classification used, any identified mineral resource is incorporated in the highest mineral potential category. This includes a broad spectrum of mineral deposits that could range from producing mines with documented reserves to well established exploration projects with identified mineral resources.

Two factors, favourability and degree of confidence, provide the basis for a widely applicable, semiquantitative classification of mineral potential that can be readily understood by land-use planners and exploration geologists alike. Data available for determining the extent of mineralization, in the exploration industry or in mineral resource assessments, generally fall into four broad categories; these are geological environments, the distribution of known mineral occurrences, geochemical data and geophysical measurements. Each category of data can be derived and interpreted independently prior to being combined into an overall metallogenic model for the deposit being sought. The "favourability" of any given category is determined by comparing the field characteristics with the criteria established in a metallogenic model. If sufficient criteria are satisfied, a favourable rating is applied to that category of data and the first step towards a higher mineral potential designation is made. When applying this to a specific tract of land, coincident favourable ratings from different categories both increases the mineral potential designation and yields a greater "degree of confidence" in that rating.

Figure 30 illustrates this classification diagrammatically for the three types of data available for the Chilko Lake Planning Area. Geological, geochemical and mineral occurrence data have been determined from the fieldwork conducted in this project and from literature research of assessment reports and previous mapping projects. "Geological" data refer to information gathered or interpreted through mapping, aerial photography or landsat imagery. "Mineral occurrence" data refer to significant visible mineralization that is worthy of further site-specific exploration. Minor mineral occurrences that provide an incentive to explore an area (as opposed to a specific site) are attributed to either the "geological" or "geochemical" data categories. This separates realistic exploration targets from areas that are merely considered prospective. Analytical information determined for significant visible mineralization is included as mineral occurrence data as this defines what commodities, visible or not, are present in the mineralization. These analyses are separate from and not considered in the "geochemistry" data set. "Geochemical" data apply to those analyses collected as an independent exploratory or prospecting tool and include the stream-sediment analyses and lithogeochemical analyses of rock samples without significant visible mineralization. In this way the favourable geochemical characteristics of known mineralization are not counted twice in the classification system and all three sources of data can be considered independent indicators of mineral potential.

Each of the three categories of data is represented within the triangle in Figure 30; if the data are deemed to be favourable for a mineral deposit relative to a metallogenic model they fall within one of the circles. Various combinations of favourability are represented by varying degrees of overlap of the circles. Greater combinations of favourable data represent greater degrees of confidence in designating higher mineral potential ratings. Higher numerical values are attributed to those areas where a greater degree of confidence of overall favourability is established. The areas of highest mineral potential, designated 6 and 5 on Figure 30, contain supportive data from all sources. The higher value of 6 is restricted to specific sites such as mines or active exploration projects where a mineral resource or reserve has been identified. Prospective areas surrounding a mine or newly discovered zones of mineralization with many favourable metallogenic characteristics, but without an identified resource in the ground, are given a classification of 5. Values of 4 and 3 are attributed to areas where supportive data come from two of the three sources. The combination of known mineralization and favourable geology has a greater exploration significance and hence a greater potential for locating mineralization; as a result this combination is given the higher rating of 4. Favourable data from only one category are designated 2; the data category can be identified with a subscript on a mineral potential map. Table 19 provides a qualitative description of each category of mineral potential and includes a statement on the perceived likelihood for future exploration. The value of indicating the potential for future exploration activities as a measure of expected land use was previously shown by McCartney *et al.* (1974) on their mineral capability maps for British Columbia.

Plus signs (+) are also used on mineral potential maps to indicate areas of *very* favourable geology, *highly* anomalous geochemistry or *very well documented* mineralization, in an effort to identify localized areas that are particularly favourable. The sphere of influence of a plus sign is generally less than 2 kilometres. Note that the area marked 3*, overlapping known mineralization and anomalous geochemistry, has generally been fitted into a metallogenic model and therefore is in an area of favourable geology, that is, it is actually in classification 5. Any data truly plotting in 3* indicate further geologic mapping, and re-evaluation are required. In some cases this area could represent interpreted extensions of mineralized zones into overburden-covered areas that are geochemically anomalous. In most instances areas marked 3 on a map indicate overlapping favourable geology and anomalous geochemistry.

Low mineral potential can also be stated with reasonable confidence by assigning a value of 1 to areas where none of the data sources indicate a favourable condition. It is important to note the sizeable difference between an I rating and any other rating. In a regional resource assessment many areas may not provide sufficiently detailed data to make a reasoned determination of mineral potential, hence values ranging from 1 through 5 may indeed be present within the areas designated I. In this study I ratings may only apply to some peripheral areas where time did not permit complete data accumulation or to extensive areas of overburden, glacial ice, or snow.

It should also be pointed out that one significant type of data was unavailable to this study as no regional airborne geophysical surveys have been undertaken in the Chilko Lake Planning Area. These surveys can be as important as geochemical surveys for locating certain deposit types and for supporting geological interpretations. A greater degree of confidence in designating mineral potential ratings could be achieved if these data were available.

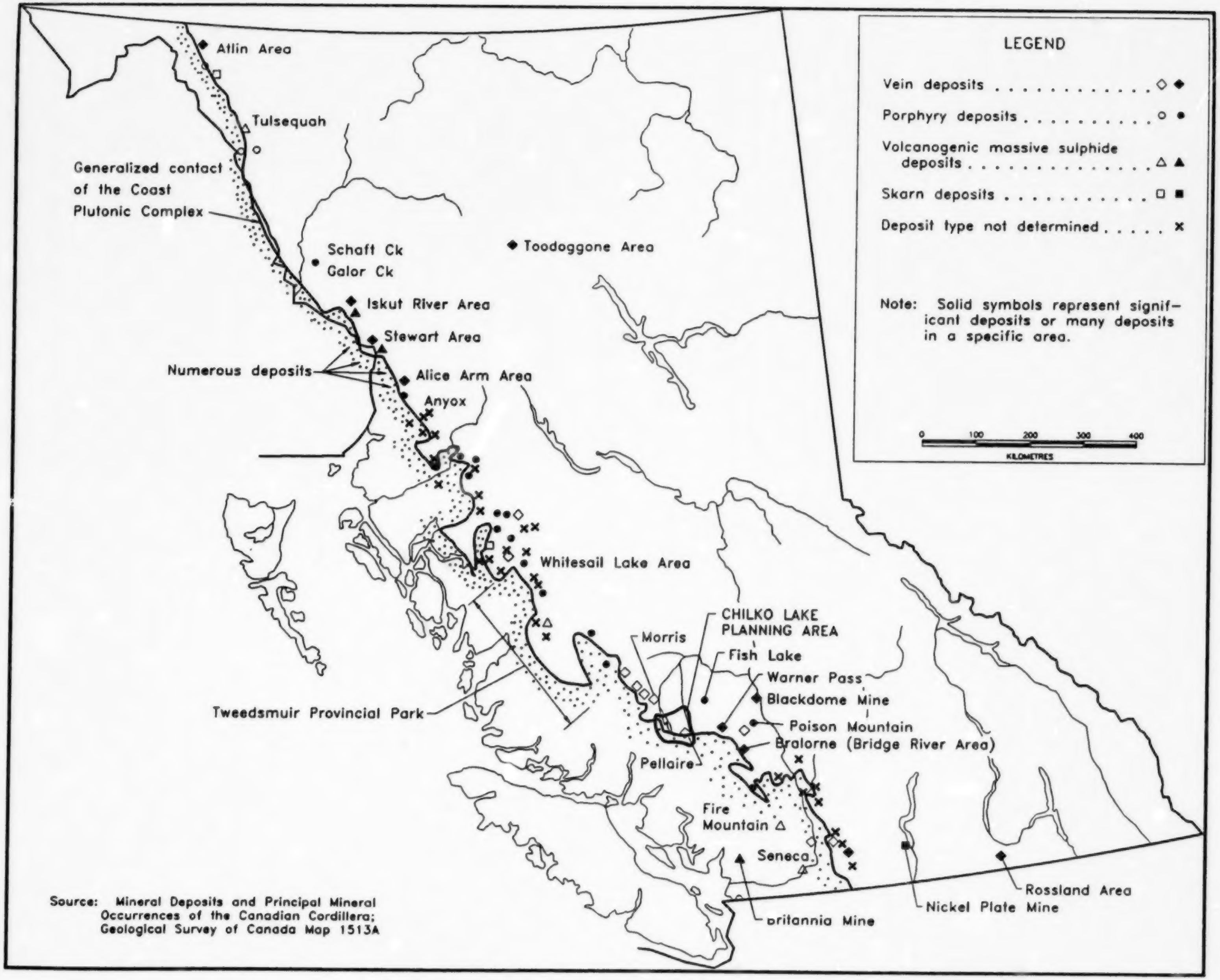
TABLE 19
QUALITATIVE DESCRIPTIONS OF
MINERAL POTENTIAL CLASSIFICATIONS

Class	Mineral Potential	Description
6	Very High	Known deposits with identified resources in the ground. Favourable supporting data from all three sources; high degree of confidence in designation. Continued exploration highly probable; potential for mine development is high.
5	High	Known occurrences in highly favourable metallogenic environment. Supporting data from all three sources; high degree of confidence in designation. Future exploration highly probable.
4	Moderate	Known or indicated mineral resources in favourable geological environment. Supporting data from these two sources specifically; moderate degree of confidence in designation. Future exploration to be expected.
3	Moderate	Favourable geological and geochemical environment, but significant mineral occurrences lacking. Supportive data from these two sources; moderate degree of confidence in designation. Future exploration likely, particularly if near areas of higher potential.
2	Moderate to Low	Supporting data from one of three sources, usually geological or geochemical; areas generally lack sufficient prospecting to identify mineralization. Moderate to low degree of confidence in designation. Reconnaissance exploration to be expected. Good potential for upgrading of classification.
1	Low	Current data is nondiagnostic for favourable metallogenic environment. Moderate to high degree of confidence in designation. Little likelihood of future exploration for deposit types considered.
I	Indeterminate	Current data is either outdated or insufficiently detailed for a reasoned determination of mineral potential. High degree of confidence in designation. Future exploration to be expected in parts of the area.

MINERAL POTENTIAL OF THE CHILKO LAKE PLANNING AREA

REGIONAL EVALUATION

As the Chilko Lake Planning Area straddles the eastern border of the Coast plutonic complex it is situated in an area of relatively high mineral potential within British Columbia, as evidenced by the numerous deposits found along this trend (Figure 31). This association, a consequence of favourable metallogenic conditions developed through subduction and terrane collision along a convergent plate margin, has long been studied to aid in understanding the metallogenic history of the Canadian Cordillera (Sutherland-Brown *et al.*, 1971).


LEGEND
Vein deposits . . . . ◇ ◆
Porphyry deposits . . . . ○ ●
Volcanogenic massive sulphide deposits . . . . △ ▲
Skarn deposits . . . . □ ■
Deposit type not determined . . . . . ×
Note: Solid symbols represent significant deposits or many deposits in a specific area.
0
100
200
300
400
KILOMETRES
Atlin Area
Tulsequah
Generalized contact of the Coast Plutonic Complex
Schaft Ck
Galor Ck
Toodoggone Area
Iskut River Area
Stewart Area
Numerous deposits
Alice Arm Area
Anyox
Whitesail Lake Area
Tweedsmuir Provincial Park
CHILKO LAKE PLANNING AREA
Morris
Fish Lake
Warner Pass
Blackdome Mine
Poison Mountain
Bralorne (Bridge River Area)
Pellaire
Fire Mountain
Seneca
Britannia Mine
Nickel Plate Mine
Rossland Area

Source: Mineral Deposits and Principal Mineral Occurrences of the Canadian Cordillera; Geological Survey of Canada Map 1513A

Figure 31. Mineral deposits adjacent to the contact of the Coast plutonic complex.

Genetic relationships between the intrusive margin, mineralization and the subduction-collision process have been noted for both porphyry deposits in west-central British Columbia (Carter, 1981) and for the porphyry and vein occurrences of the Taseko Lakes (92O) and Pemberton (92J) map areas (Leitch and Godwin, 1988; Woodsworth *et al.*, 1977). The latter study bordered on the Chilko Lake area and suggested that most of the mineral deposits, in particular the vein occurrences, formed under the influence of thermal gradients developed during cooling of the northeastern flank of the Coast plutonic complex. McMillan (1976) has also noted coincident ages between mineralization, alteration and Coast Range intrusions in the Taseko River valley 15 kilometres east of the Chilko Lake Planning Area. Extensive faults developed during terrane convergence were significant in localizing both the vein and porphyry types of mineralization along this trend. Volcanogenic massive sulphide deposits, although not genetically related to the intrusive rocks, have been preserved in volcanic rocks on the flanks of, or in 'roof pendants' within the Coast Complex. It is evident that metallogenic environments favourable for porphyry, vein and volcanogenic massive sulphide deposits are related either genetically or spatially to the border of the Coast plutonic complex; these environments can be expected in the Chilko Lake Planning Area.

Figure 31 illustrates that the deposits along the Coast Complex contact zone are strongly clustered both south of Taseko Lakes (from the Warner Pass area southward) and north of Chilko Lake (from the Whitesail Lake area northward). The intervening zone, from Taseko Lakes to Whitesail Lake, has an equally high regional mineral potential. This area has historically seen less exploration activity, particularly in the last two decades, due to the rugged terrain, general lack of access and the alienation of exploration and mining in the extensive area covered by Tweedsmuir Provincial Park. The lower discovery rate in this area is interpreted as being primarily due to the lack of exploration. Its mineral potential is considered as high as that to the south and north. Northcote *et al.* (1983) previously published a mineral potential map of the Chilko Lake Planning Area based on the regional geological and mineral occurrence data available in the literature at that time and using the classification system of McCartney *et al.* (1974). The trends of mineral potential established on their map confirm the continuity of zones of higher potential into adjacent areas, particularly to the east into the Taseko River valley.

Table 20 summarizes estimates of the size and grade of deposit types that can be expected in the Chilko Lake Planning Area. The deposit types considered display a wide range of sizes throughout the Canadian Cordillera; the estimates provided are based primarily on comparisons with known deposits or developed prospects in similar 'training tracts'. They approximate reserves at properties currently being developed or resources that could be upgraded into reserves with future changes in economics or infrastructure, or through further exploration.

Analogous vein and porphyry deposits are well known near the Chilko – Taseko Lakes area as well as in similar environments in northern British Columbia; they provide a measure of what could be developed into mineral reserves in the planning area. Comparisons with known massive sulphide and skarn deposits are not as reliable, particularly with respect to size, therefore these analogies in Table 20 should be viewed simply as examples of deposits known elswewhere in the Cordillera.

TABLE 20
SIZES OF DEPOSITS POTENTIALLY FOUND IN THE CHILKO LAKE PLANNING AREA

Type of Deposit	Size and Grade	Training Tract Deposits
Mesothermal and epithermal precious metal veins	80 000–1.5 million tonnes 15–25 grams per tonne Au 30–80 grams per tonne Ag	Stewart area Blackdome mine Bralorne area Pellaire (Lord River)
Porphyry copper-molybdenum-gold	200 million tonnes 0.25–0.35 per cent Cu 0.15 per cent Mo 0.3–0.4 gram per tonne Au	Fish Lake Poison Mountain Stikine area Highland Valley
Skarn* (precious metal bearing)	1.8 million tonnes† 7.5 grams per tonne Au	Tillicum Mountain
	8.9 million tonnes 4.56 grams per tonne Au	Nickel Plate mine
Volcanogenic massive sulphide*	1–15 million tonnes 0.5–2.0 per cent Cu 0.5–5.0 per cent Zn 0.1–2.0 per cent Pb 0.5–2.0 grams per tonne Au 5–40 grams per tonne Ag	Seneca (Harrison Lake) Britannia mine Westmin Resources Myra Falls mine

* Estimates of these deposit sizes are less reliable as they are not based on analogous training tracts. *See* comments in text.

† Proven and probable reserve — Source: George Cross Newsletter, November 17, 1988

The size and grade estimates reflect models of what explorationists could reasonably anticipate discovering in the Chilko Lake Planning Area. The estimates may represent potential reserves or potential resources. Economic, technologic and infrastructure factors play a large part in determining whether deposits of this size represent mineable reserves or an inventory of future resources.

Designations of mineral potential made in the following section are focused on predicting the probability of locating deposits of the size and grade of the examples outlined in Table 20. There is always the possibility of locating deposits larger or richer, and hence more valuable, than those illustrated in the table. Furthermore, it is normal for underground development to commence on a deposit as soon as an economic reserve has been established: subsequent exploration frequently results in the discovery of additional reserves and extends the life of the mine.

It has been clear from the outset of this study that the Chilko Lake Planning Area is located on a trend of regionally high mineral potential. The following discussion is intended to confirm in more detail the specific areas of higher potential within the planning area itself.

CHILKO LAKE PLANNING AREA EVALUATION

Figure 32 (in pocket) presents a mineral potential map of the Chilko Lake Planning Area based on the classification system developed earlier in this chapter. Not surprisingly, the general trends of mineral potential patterns on this map parallel those of the geological formations (Figure 5). Zones of moderate to high potential follow northwesterly trending favourable geological features (fault zones, stratigraphic horizons) and broaden where faults splay into more complex patterns or where intrusive bodies cut the surrounding layered rocks. Smaller zones of higher potential lie within these areas, centred on localities with known mineralization or highly anomalous geochemistry. Areas of lowest potential are located where no favourable characteristics were determined, such as the cores of intrusive bodies in the Coast plutonic complex or within the metal-poor sedimentary rocks of Unit LK_q.

Trends of higher mineral potential shown on Figure 32 are similar to those of Northcote *et al.* (1983; Figure 71) but are much more refined due to the wealth of detailed data collected in this study. Also the classification system used here has a slightly different focus which relates more directly to known field characteristics of the area.

The classification system used here can be applied separately to each metallogenic model considered. Different metallogenic symbols for each known mineral occurrence are used on Figure 32 to illustrate the potential being considered in the moderate to high categories. The metallogenic models considered in the "less certain" favourable areas are mentioned in the following discussion of each classification of mineral potential.

CLASS 6 (VERY HIGH) MINERAL POTENTIAL

The only area identified as having the highest mineral potential ranking (Class 6) is the Pellaire property where a gold-silver mineral resource in a mesothermal vein system has already been established. Significant exploration potential is indicated in the area of past workings and there are known but under-explored veins in the immediate vicinity which present further potential for mineralization; these are included within the area of Class 6 designation surrounding the deposit. In addition to the known mineralization and favourable geological setting, anomalous levels of geochemical indicators, notably gold and silver, were detected in this area. Detailed exploration of this deposit resumed in 1987 and can be expected to continue; the likelihood of future development is high.

CLASS 5 (HIGH) MINERAL POTENTIAL

Areas with a high mineral potential based on three independent indicators, but lacking defined resources in the ground, are located over the remaining known significant mineral occurrences. These five areas are referred to as Charlie, Twin Creek, Tarn Creek, Alexis and Daisie. Mineral claims existed on the Charlie group, Alexis and Daisie mineral occurrences prior to this study; the Twin Creek and Tarn Creek areas, and the new mineralization at Alexis Creek, were staked immediately following publication of interim results of this study (McLaren, 1986a, 1987a). Exploration will probably continue on all of these prospects in years to come. The potential for at least one of these areas to be upgraded to Class 6 appears to be good.

CHARLIE AREA

The broadly mineralized area containing the Charlie group has potential for both porphyry copper-molybdenum (±gold) mineralization and mesothermal to epithermal gold-silver-copper-bearing veins. The strongly faulted and fractured volcanic hostrocks that have been cut and altered by a variety of intrusions confirm the favourable geologic character of the area for both styles of mineralization. The stream-sediment geochemical survey clearly defined the area as having numerous copper anomalies and specific areas anomalous in gold. Lithogeochemical data also confirmed anomalous metallogenic indicators. Mineralization has previously been documented over the entire area in settings characteristic of the porphyry copper-molybdenum and gold-silver vein metallogenic models. The Class 5 mineral potential designation has been drawn primarily around the known mineral occurrences; note that much of the surrounding area has been designated as 3^{++}, that is, a highly favourable geological and geochemical environment without known significant mineral occurrences. There is a strong possibility that continued exploration would locate further mineralization and expand or upgrade the Class 5 area. The area of highest porphyry copper-molybdenum-gold potential is located in the Tchaikazan valley and is largely obscured by overburden, however the metallogenic environment established by past exploration in this area warrants a Class 5 or 3^{+} designation.

TWIN CREEK AREA

The Class 5 designation in the Twin Creek area is based on strong indications of the existence of a mesothermal or epithermal precious metal vein deposit. The arsenic-bearing vein system located in Twin Creek and the quartz veins carrying copper-gold mineralization on the ridge crest to the west, clearly demonstrate this potential. The Twin Creek vein system has significant unexplored potential for vein extensions beneath the drift-covered valley floor and lies in a very favourable position adjacent to a major fault and an intrusive contact. The intrusive contact zone carrying the copper-gold mineralization occurs in a metallogenic setting similar to areas undergoing extensive exploration in the Taseko River valley 20 kilometres to the east. Recognition of arsenic and lead geochemical anomalies contributed to the discovery of these occurrences in the course of fieldwork on this project and has also led to claim staking in this area in the past. The proximity to known gold vein mineralization at both the Pellaire and the Charlie prospects, and the lack of detailed evaluation of these new occurrences in such a favourable metallogenic environment also support a designation of high mineral potential throughout the Twin Creek area.

TARN CREEK AREA

The quartz-vein stockwork zone of copper mineralization discovered while prospecting north of Yohetta Lake represents an isolated area of high mineral potential for a porphyry copper-gold deposit. The favourable geological characteristics (including rock types, alteration assemblages and structural features) and style of mineralization are typical of the porphyry deposits known just to the east at Fish Lake and Poison Mountain. Geochemical anomalies were determined in the stream sediments and in altered or weakly mineralized zones surrounding the main copper occurrence. The area is interpreted as the uppermost environment of a porphyry copper system and hence has significant untested potential at depth.

Favourable criteria for the occurrence of a mesothermal or epithermal vein deposit are also present in this valley. The stockwork mineralization may have developed adjacent to a large vein system, possibly contained within the northeasterly fault zone in the valley. This fault zone is known to contain well fragmented rocks that have been recemented by hydrothermal precipitates and should be considered as a potential host for vein deposits. Pending a detailed evaluation of this valley, the mineral potential must be considered high.

ALEXIS AREA

The mercury-copper-arsenic mineralization in the Alexis area is a typical surface expression of an epithermal precious metal vein deposit. There are numerous similarities between this occurrence and the much better documented deposits of the Warner Pass and Bridge River areas to the southeast. This mineral occurrence is a relatively recent find that has a significant exploration potential, as shown by the discovery of new mineral occurrences in the course of this project that extended the zone of known mineralization well beyond that previously documented. Strong geochemical anomalies were noted in stream sediments collected peripheral to the area. Chip samples of altered but unmineralized rocks also contain anomalous levels of metallogenic indicators. The Tchaikazan fault zone, containing well fractured volcanic rocks and numerous small intrusions, is a highly favourable environment for mineralization. The Class 5 area is restricted to the main trend of mineralization; this is surrounded by Class 3^{++} areas with highly favourable geological and geochemical characteristics that simply lack the detailed prospecting necessary to locate new mineral occurrences.

DAISIE AREA

The Daisie area has a high potential for copper-tungsten skarns as demonstrated by the scattered mineral occurrences in the Deschamps valley. The thick section of Triassic calcareous rocks, two phases of intrusive activity and large fault zones in the area are all favourable elements in the skarn metallogenic model applied here. Stream-sediment geochemical anomalies in copper, molybdenum and tungsten clearly identify the mineralized zone within a broader area of elevated indicator elements. Previous exploration, including diamond drilling, has documented sufficient mineralization to support the skarn metallogenic model. Additional exploration potential exists in extensions of the favourable host rocks that are hidden beneath the broad, overburden-covered, valley floor. The high potential rating is applied to an area surrounding the known mineralization while a lower rating (Class 2) is assigned to the areas of overburden-covered Triassic rocks.

CLASS 4 (MODERATE) MINERAL POTENTIAL

The Vick gold prospect on the northeast edge of the study area has been designated Class 4 or moderate mineral potential. A significant gold-bearing quartz-vein system fits the precious metal mesothermal vein model. This prospect lies outside the area covered by the stream-sediment survey and the few rock-chip samples collected here are all related to mineralized zones hence applicable geochemical data are not available. However the gold-bearing quartz veins hosted by an extensive fracture system close to a fault zone of regional significance provide evidence supporting a Class 4 designation. Additional sampling would probably provide the geochemical data necessary to raise this classification to Class 5. As little work was done in the vicinity of this showing and much of the surrounding area is covered by talus and overburden, the Vick occurrence is isolated within an area designated Class 1 (insufficient data). The area has been intermittently explored for many years and exploration is likely to continue in the future.

CLASS 3 (MODERATE) MINERAL POTENTIAL

Areas designated as having a Class 3 or moderate mineral potential delineate the general trends of the major fault zones and lines of intrusive stocks reasonably well. As fault zones and intrusions are often prominent features of metallogenic models, these areas are favourable geological environments and it is not surprising that they are geochemically anomalous. The main areas with a Class 3 potential are the Tchaikazan fault zone, related structures between the Tchaikazan and Lord River valleys, the Stikelan fault zone and the trend of intrusions extending from the head of Tredcroft Creek to the Spectrum Peak area. Considerable claim staking was generated in Class 3 areas by publication of interim results from this project. Exploration of these claims is at a preliminary stage; continuity of future exploration in Class 3 areas will vary considerably but will be most intensive close to known mineral occurrences. Any future exploration successes in Class 5 areas will also stimulate further evaluation of the surrounding Class 3 areas.

TCHAIKAZAN FAULT ZONE

The numerous sub-parallel and anastamosing faults comprising the Tchaikazan fault zone represent an extensive and well developed conduit system for migration of hydrothermal fluids and a zone of crustal weakness where intrusive bodies have penetrated. These favourable geological characteristics have led to mineral occurrences, hydrothermal alteration zones and widespread geochemical anomalies along the length of the zone. Documented mineralization is primarily in the epithermal or mesothermal vein category, both within the Chilko Lake Planning Area and to the east in the Taseko valley, however porphyry-style mineralization occurs where larger intrusive bodies are present. The correlation of this fault zone with the well mineralized Bralorne fault system (Monger, 1986) also highlights the regional mineral potential of this structure.

Numerous geochemical anomalies have been identified surrounding the high-potential Charlie area centred on a segment of the Tchaikazan fault zone. The original Regional Geochemical Survey identified this section as containing the most geochemical anomalies in the entire study area. This favourable geochemical environment was confirmed by both stream-sediment and rock-chip analyses determined in this study. Eocene felsite intrusions are specific to this part of the study area and may have enhanced the metallogenic characteristics locally. Minor mineral occurrences throughout the area are also favourable indicators of the mineral potential.

To the northwest traces of mineralization and geochemical anomalies occur sporadically along the faults as far as Chilko Lake. The Mount Goddard copper occurrence, located within this zone in an area of complex faulting and intrusive activity, is noted as a particularly favourable environment (Class 3^{++}) within this broader area of moderate potential.

Farther to the northwest, zones classified as having moderate potential, but again with particularly favourable indicators, follow the Tchaikazan fault zone and surround the mineralization in the Alexis area. Prospecting on the lower forested slopes here may lead to the discovery of new mineral occurrences and raise the classification of this area. Anomalous geochemical indicators along this fault trend between the Alexis area and Chilko Lake, and in limonitic zones on a splay of the fault, highlight other areas of Class 3 potential.

TCHAIKAZAN RIVER TO LORD RIVER AREA

This area is underlain by a package of faulted rocks with similarities to the Tchaikazan fault zone, and has the added favourable factor of being immediately adjacent to the Coast plutonic complex. Two areas of high mineral potential (the Twin Creek and Pellaire prospects) also occur along this trend. This environment has potential primarily for vein and porphyry mineralization, however some geological and geochemical characteristics of the rocks exposed in the Tchaikazan River valley suggest the presence of a volcanogenic massive sulphide environment.

Anomalous geochemical data have been obtained in this and previous studies in the Tchaikazan, Falls and Discord valleys. Major fault zones with associated pyritic alteration halos in both the volcanic and intrusive rocks are similar to those in Taseko valley to the east. A mineralized quartz vein with anomalous concentrations of precious and base metals in Discord valley reinforces the vein and porphyry mineral potential, particularly peripheral to the protruding lobe of Coast plutonic rocks in this area.

A favourable geologic environment for volcanogenic massive sulphide deposits is present on the northern slope of the Tchaikazan valley and is supported by anomalous geochemical indicators for this deposit type; this area is therefore included within the zone of moderate mineral potential.

STIKELAN FAULT ZONE

The Stikelan fault zone represents a geological environment similar to the Tchaikazan fault zone. Minor occurrences of precious metal vein mineralization are known adjacent to the fault in areas to the northwest of the Chilko Lake Planning Area (Tipper, 1969). A segment of the fault zone at the head of Girdwood and Tredcroft creeks contains sufficient geochemical indicators to define a moderate mineral potential. The occurrence of an intrusive stock adjacent to this zone at the head of Tredcroft Creek further enhances the potential for both vein and porphyry-related mineralization. Minor copper mineralization was found adjacent to the intrusive and previous exploration has indicated similar occurrences nearby.

Another small zone of moderate mineral potential is located within the fault immediately north of Franklyn Arm. An isolated lithogeochemical anomaly and a minor copper occurrence in a pyritic felsic volcanic sequence in this zone defines favourable geological and geochemical characteristics for volcanogenic massive sulphide or vein deposits. The favourable geological features continue south of Franklyn Arm but geochemical anomalies were not detected in this area.

TREDCROFT CREEK TO SPECTRUM PEAK AREA

The belt of intrusive stocks aligned in a northwesterly trend between Tredcroft Creek and the Spectrum Peak area represent a favourable geologic environment for the development of porphyry deposits and possibly for vein occurrences. Minor mineral occurrences distributed along this trend attest to this potential. These data are supported by geochemical anomalies detected in this project and in a number of exploration programs in this area in the past. Southwest of Spectrum Peak vein mineralization and anomalous geochemical indicators adjacent to one stock suggest a particularly favourable environment.

At the western tip of the zone of moderate potential southwest of Spectrum Peak, a favourable volcanogenic massive sulphide environment is defined by both geological and geochemical indicators. The geological environment continues westward to the shore of Chilko Lake (Class 2^{+}) but lacks geochemical support in this area.

CLASS 2 (MODERATE TO LOW) MINERAL POTENTIAL

Areas with potential for mineral occurrences based on only one line of evidence cover much of the remaining volcanic and sedimentary strata throughout the planning area. This designation is based on a perceived favourable geologic environment; much of the area has not been prospected in sufficient detail to confidently assign a low mineral potential. Two important geological features in support of this designation are the contact zone of the Coast plutonic complex and the faulting prevalent throughout most of the volcanic and sedimentary section. The Class 2 designation extends a short distance into the intrusive complex, reflecting known mineralization within the intrusive border phase at the Pellaire prospect and to the east in the Taseko valley. Some isolated minor mineral occurrences and geochemical anomalies are known throughout the centre of the study area and fall within this zone; these are usually indicated by the geochemical subscript (A) for Class 2 designations on the mineral potential map (Figure 32).

The area north of Long Valley is not believed to be strongly faulted (based on limited mapping) but stream sediments in this area have an unusually high concentration of a variety of elements (zinc, strontium, vanadium, titanium). Until the reason for this geochemical enrichment is clear the area has been given a moderate to low mineral potential designation. This designation is also given to the favourable volcanic environments where potential for a massive sulphide deposit has been identified, such as north of Franklyn Arm or along the shoreline of Chilko Lake southwest of Mount Goddard.

Some claims were staked to cover geochemical anomalies in Class 2 areas following publication of data from this project. Continued reconnaissance exploration can be expected in these areas; should exploration efforts in adjoining areas of higher potential prove successful, further exploration of Class 2 areas should be anticipated.

CLASS 1 (LOW) MINERAL POTENTIAL

The lowest class of mineral potential, Class 1, is assigned to areas underlain by three geological units, namely most of the Coast Range plutonic rocks in the study area, the relatively pure quartzose and cherty clastic sediments of Unit LK_q located south and east of Franklyn Arm, and the massive, unfaulted, subaerial volcanic rocks of Unit LK_{pv} west of Chilko Lake (Figures 5 and 6). Geochemical responses in these areas were uniformly low and no mineral occurrences are reported. The geological environment does not appear to fit the metallogenic models considered in this study. Admittedly the intensity of mapping, prospecting and sampling in the Coast Complex was less than in other areas, however, the field data and comparisons with training tracts suggest a low mineral potential. Nevertheless, where splays of fault zones extend into the volcanic rocks of Unit LK_{pv} some mineralization or geochemical anomalies were detected and further prospecting in this unit may upgrade the mineral potential designation. In general however, future exploration in these areas is likely to be contingent on new discoveries in adjacent rocks.

CLASS I (INDETERMINATE) MINERAL POTENTIAL

The periphery of the map area is designated as Class I, meaning that there are insufficient data to assess the mineral potential. Regional mapping and Regional Geochemical Survey data are available but are not sufficiently detailed to provide a sound basis for informed land-use decisions. Note that zones of established moderate and high mineral potential are truncated by the Class I designation. It is a safe assumption that further study would extend the favourable zones. This situation is comparable to that illustrated in Figure 31, where the lack of exploration along the border of the Coast Complex between Taseko and Whitesail Lakes gives the misleading impression of regionally low mineral potential, but in reality, it represents insufficient data to define it. Future exploration in these areas is likely, but will tend to be intermittent until sufficient data are gathered to focus exploration efforts.

MINERAL POTENTIAL: SUMMARY

It has been over six decades since Dolmage (1925) concluded that the geology of the Chilko Lake area could be expected to host mineral deposits. The intermittent exploration and mapping conducted during that time, and the progressive development of Cordilleran plate tectonic and metallogenic concepts in recent years, reinforce Dolmage's interpretation and further delineate the styles of mineralization to be expected. The detailed field evaluation carried out in this project confirms the existence of mineral occurrences in the Chilko Lake Planning Area and indicates where continued exploration efforts will have the best opportunities for finding future mineral resources.

Mesothermal to epithermal vein deposits of gold, silver and copper offer the greatest potential for future mineral developments in the planning area. In four of the six areas categorized as having high or very high mineral potential, the designations are primarily based on the likelihood of discovering gold-silver vein deposits; a fifth area includes gold vein deposits as a secondary target. The Pellaire prospect already contains a drill-indicated resource of 31 000 tonnes of gold-silver ore in the ground. Similar deposits are being actively explored and developed in adjacent areas of comparable geology (Bridge River area) as well as elsewhere in British Columbia. Prospecting of the major fault zones, particularly along the contact of the Coast plutonic complex or near intrusive bodies, is likely to result in further discoveries. A granodiorite stock adjacent to the Tchaikazan fault zone in Stikelan Pass (immediately north of the map area; McLaren,1987b) may be one such area.

There is also significant potential for porphyry copper-molybdenum-gold deposits in the planning area, as two of the high mineral potential zones (Charlie and Tarn Creek) contain porphyry-type metallogenic environments; two well documented deposits (Fish Lake and Poison Mountain) occur nearby in similar geological settings. Such deposits may occur anywhere that an intrusion cuts through the sedimentary and volcanic rocks, hence a localized zone of high potential may occur within a broad zone of apparently lower potential. The Tarn Creek occurrence is a prime example (Figure 32). Immediately north of the planning area two intrusions are surrounded by limonitic alteration zones (one on Mount Nemaia, the other on the north side of Stikelan Pass) that are clearly visible from a distance; these may represent prospective porphyry environments.

The potential for copper-tungsten skarn and volcanogenic massive sulphide deposits is not as well documented as the other deposit types in the Chilko Lake Planning Area. However a single massive sulphide deposit, even though a less likely exploration target, may have greater potential and impact within the present and near-future economic climate affecting the mining industry. These two deposit types must be fully considered in any mineral resource assessment. One of the high potential areas (Daisie) is based on the existence of skarn mineralization and the metallogenic environments for both skarn and massive sulphide deposit models are clearly present in the planning area.

The discovery of four significant new mineral occurrences (Tarn Creek, Twin Creek, Discord Creek and Alexis), as well as numerous minor occurrences, during the field work for this project, adds credibility to Dolmage's assessment of the overall high mineral potential of the region. Given that many valleys and mountain ridges remain unprospected in this large, rugged area, the probability that continuing exploration will lead to the discovery of new mineral occurrences must be considered high. Numerous gossanous alteration zones were noted while mapping the area (Figure 5) and many of these were not fully evaluated. Areas designated Class 2 on Figure 32 contain many such zones that warrant closer examination before a low mineral potential can be confidently assigned to them.

Independent confirmation of the perceived high mineral potential indicated in this study was demonstrated by the exploration industry through extensive claim staking following the preliminary publication of field data (McLaren 1986a-c, 1987a-c). The new mineral occurrences discovered were quickly staked and large areas designated Class 3 or 2 mineral potential were claimed. Preliminary exploration on these claims is now in progress.

This mineral resource assessment suffers from a liability inherent in all mineral potential studies in that it cannot predict future trends in mineral economics or the development of metallogenic concepts that may change the thrust of mineral exploration programs. The continuing evolution of metallogenic concepts in the Canadian Cordillera will lead to the development of new ore-deposit models. These models, used in concert with evolving technologies and changing societal needs, could ultimately result in discoveries that may not have been considered here. This assessment is valid only within the framework of current knowledge. Forethought in land-use management planning allows for recurring mineral resource assessments, such as recommended in the United States *Wilderness Act*, so that new metallogenic concepts can be applied and portions of wilderness areas can be reassessed when needs dictate.

The final conclusion of this project is essentially the same as Dolmage's evaluation over 60 years ago, namely that the Chilko Lake Planning Area has a sufficiently high mineral potential that continued exploration can be expected and further mineral discoveries, comprising a potentially economic mineral resource for British Columbia, will be made. It is hoped that this report provides the information required by both intended audiences in the pursuit of their goals, that is, for industry geologists to conduct mineral exploration in their search for ore deposits and for land-use planners to determine rational park proposal boundaries and park planning strategies.

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APPENDIX A

STREAM SEDIMENT GEOCHEMICAL SURVEY

SAMPLING PROCEDURES

Active stream sediments were collected using aluminum scoops and stored in kraft paper sample bags; these were then placed in plastic bags. Samples were air dried in the field where possible. Sample-site data were recorded on field computer cards; this included location (UTM coordinates, elevation, *etc.*), sediment characteristics (composition, texture, *etc.*), stream characteristics (source, depth, width, water colour, etc.) and possible sources of metal contamination. A duplicate field sample was collected from one of each 17 sites sampled.

Samples were generally collected at the break in slope, or higher, depending on accessibilty. Channel bank material was usually glacial till or locally derived talus; soil development is poor in much of the study area. Dendritic drainage patterns, typical of a youthful mountainous topography, characterize the area. Stream gradients range from steep channels draining mountain slopes to moderate or gentle gradients in the larger creeks or rivers. Water sources are generally glaciers, icefields or snow accumulations; seasonal runoff peaks in early August.

SAMPLE PREPARATION

Samples were delivered to Kamloops Research and Assay Laboratory Limited for preparation prior to analysis. Samples were dried and sieved to –80 mesh (<177 microns). The samples were handled in batches of 20. A laboratory duplicate was randomly inserted in each batch by splitting a prepared sample into two; the duplicate was then treated independently in any subsequent analyses. A laboratory standard reference sample supplied by the Geological Survey of Canada (the same standards used in the government Regional Geochemical Surveys) was also included in each batch of 20 samples; each batch of samples forwarded to the analytical laboratory therefore included 17 field samples, one field duplicate, one laboratory duplicate and one standard reference sample. The –80 mesh sample fractions were stored in plastic vials; sample weights were generally greater than 20 grams, however one sample contained insufficient sample to permit a separate gold analysis.

ANALYTICAL PROCEDURES

All samples were shipped to Chemex Labs Limited in North Vancouver for 30-element inductively coupled plasma (ICP) analysis and separate gold and mercury analyses. The ICP analysis utilizes an aqua regia digestion on 0.5 gram of sample. This digestion may be incomplete for many minerals hence the values reported for Al, Sb, Ba, Be, Ca, Cr, Ga, La, Mg, K, Na, Sr, Th, Ti, W and V can only be considered semi-quantitative. Detection limits for this ICP package are provided in Table 2 (Chapter 3). Mercury was analyzed using a flameless atomic absorption technique. Gold determinations, performed on a 10-gram sample, consisted of a fire assay followed by neutron activation analysis. Analytical results for samples taken from streams draining the Coast plutonic complex are given in Table A-1 while Table A-2 lists data from the volcanic and sedimentary assemblage.

SAMPLING AND ANALYTICAL PRECISION

The field and laboratory duplicates inserted in the analytical process allow an estimation of the variances introduced in the data due to sampling and analytical procedures. Thirty-two pairs of duplicate analyses, for both field and analytical duplicates, were plotted according to the method of Thompson and Howarth (1978; Figures A-1 and A-2). This method allows for testing of precision against empirical levels for limited numbers of duplicate samples (less than 50) and it attempts to account for changes in analytical reproducibility over wide concentration ranges. The test applied determines if precision is 10 per cent or better. If the duplicate analytical data comply with an empirical specification representing a 10 per cent precision then 90 per cent of the data will fall below the line marked d90 in Figures A-1 and A-2.

In almost all cases both analytical and sampling precision were determined to be better than 10 per cent, a level considered acceptable in mineral exploration surveys. Figure A-1 provides examples of plots for copper and zinc analyses. Two elements, lead and arsenic, indicated a precision poorer than 10 per cent; this is largely due to low analytical precision near the detection limit. Figure A-2 illustrates the arsenic data as an example. Somewhat spurious results in lower concentration ranges were obtained for a few elements (barium, titanium) because data were reported in increments of 10 ppm.

This test indicates that variances attributable to the sample media collected in the field and to the analytical procedures are both at acceptably low levels, and the residual variances between samples can be confidently attributed to geological parameters.

A true test of the absolute accuracy of the analytical procedure is not possible using the standard reference materials supplied by the Geological Survey of Canada because the accepted values for these materials have been determined using an atomic absorption procedure while this project utilized an ICP analysis; different sample digestions were also used. Table A-3 compares mean values of standard reference materials obtained in this project with the accepted values for elements determined in both surveys. In most cases comparable values have been obtained with the ICP analysis. A major difference is present in barium analyses; the markedly low values obtained using the ICP analysis reflect the partial dissolution of material in the acid digestion used.

DATA MANIPULATION

The stream sediment data were initially segregated into two data populations based on the geologic provenance of the samples. These populations represent samples collected from areas draining the intrusive rocks of the Coast plutonic complex and samples collected from areas underlain by volcanic and sedimentary rocks. Histogram and probability plot analysis of Sinclair (1976) was then applied to each

TABLE A-1
STREAM SEDIMENT DATA FROM THE COAST PLUTONIC COMPLEX

Sample No.	Au ppb	Al %	As ppm	Ba ppm	Ca %	Co ppm	Cr ppm	Cu ppm	Fe %	Hg ppb	K %	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sr ppm	Ti %	V ppm	Zn ppm
190	0.5	0.75	5	30	0.66	8	44	26	4.71	410	0.06	0.32	239	0	0.04	8	870	0	28	0.11	160	20
191	1.0	1.17	10	70	0.53	9	21	22	2.11	60	0.07	0.58	397	1	0.02	9	520	0	33	0.11	46	30
192	13.0	0.72	5	40	0.51	7	20	15	2.18	50	0.07	0.35	222	0	0.03	5	590	0	24	0.09	52	20
193	81.0	0.56	10	20	0.53	6	23	33	2.28	30	0.07	0.25	158	1	0.03	4	580	0	23	0.08	54	10
194	8.0	1.00	5	20	0.82	8	27	26	1.94	40	0.05	0.53	225	0	0.02	7	570	0	41	0.13	61	20
195	0.5	1.14	10	30	0.72	8	27	20	2.01	50	0.05	0.59	244	0	0.02	8	590	0	44	0.13	59	20
197	2.0	2.37	10	80	1.04	16	55	33	3.31	60	0.05	1.24	501	1	0.09	20	680	0	64	0.14	91	50
348	3.0	2.37	40	130	0.90	16	23	58	4.16	60	0.15	0.94	683	0	0.06	17	730	8	55	0.15	83	70
350	20.0	1.71	10	70	0.69	19	22	58	4.14	30	0.08	0.97	581	0	0.04	13	620	0	44	0.15	82	50
351	7.0	0.57	5	40	0.44	4	16	12	3.24	20	0.07	0.25	200	0	0.03	3	660	0	23	0.08	78	20
352	1.0	1.02	5	40	0.75	4	20	13	3.42	20	0.08	0.21	149	0	0.11	2	510	0	45	0.07	93	10
353	1.0	1.40	5	100	0.45	8	25	20	4.29	30	0.16	0.55	446	0	0.04	11	690	0	32	0.12	94	40
354	0.5	0.41	5	40	0.39	2	5	3	2.33	20	0.05	0.16	180	0	0.01	1	1030	0	25	0.05	53	20
355	5.0	0.42	5	50	0.48	3	7	5	3.31	20	0.07	0.19	240	0	0.01	1	1390	0	29	0.07	74	20
356	0.5	0.52	5	50	0.36	3	9	4	2.07	20	0.07	0.22	190	0	0.01	2	840	0	24	0.06	51	20
358	0.5	0.25	5	40	0.39	3	4	7	3.32	20	0.04	0.10	214	0	0.00	0	970	0	25	0.05	76	20
359	0.5	0.25	5	30	0.31	1	2	0	1.14	20	0.03	0.11	121	0	0.01	1	820	0	17	0.05	28	10
360	1.0	0.65	5	50	0.35	8	37	15	7.49	40	0.05	0.24	633	0	0.00	3	950	0	23	0.09	211	30
362	0.5	0.29	5	50	0.34	3	26	5	3.11	20	0.04	0.17	151	0	0.00	3	930	0	25	0.06	64	20
363	0.5	0.52	5	130	0.37	3	10	3	1.28	30	0.07	0.32	190	0	0.00	5	970	0	49	0.07	31	20
364	0.5	0.52	5	40	0.47	3	12	6	1.75	20	0.06	0.23	160	0	0.03	2	780	0	21	0.08	49	10
365	0.5	1.21	10	70	0.36	8	42	18	4.82	50	0.10	0.42	418	1	0.02	6	950	0	21	0.12	152	30
366	0.5	0.31	5	30	0.48	5	34	15	5.28	30	0.03	0.14	191	0	0.01	3	930	0	17	0.06	149	10
367	0.5	0.46	5	30	0.39	5	32	11	4.63	20	0.07	0.24	215	0	0.02	3	580	0	16	0.07	109	10
368	0.5	0.43	5	30	0.48	3	21	3	2.49	20	0.08	0.22	183	0	0.02	4	670	0	14	0.06	60	10
369	0.5	0.36	5	30	0.40	4	22	8	3.04	20	0.07	0.19	130	0	0.02	3	770	0	16	0.06	82	10
370	3.0	0.37	5	40	0.41	3	19	8	2.29	20	0.08	0.19	131	0	0.02	3	850	0	17	0.06	59	10
371	0.5	0.89	20	40	0.69	8	27	6	2.03	30	0.09	0.36	169	0	0.06	7	440	0	32	0.09	51	10
373	0.5	0.84	10	110	0.61	6	22	2	2.56	30	0.09	0.41	257	0	0.03	7	1100	0	42	0.09	70	20
374	2.0	0.43	5	40	0.49	4	20	3	3.07	30	0.06	0.27	187	0	0.01	5	920	0	18	0.07	82	10
376	2.0	0.47	5	30	0.55	3	26	5	2.90	30	0.06	0.23	159	0	0.03	4	790	0	21	0.07	98	10
377	0.5	0.68	10	30	0.59	4	23	10	2.56	40	0.07	0.33	234	0	0.04	6	780	0	19	0.12	67	20
484	0.5	0.64	5	10	0.52	5	9	8	3.58	20	0.07	0.25	237	0	0.01	2	510	0	26	0.09	65	20
485	0.5	1.02	5	40	0.64	7	14	8	2.86	20	0.09	0.48	415	0	0.01	4	680	2	45	0.12	51	50
486	0.5	0.45	5	20	0.49	5	45	17	5.56	10	0.05	0.16	161	1	0.03	4	800	0	18	0.08	147	10
487	0.5	1.12	5	60	0.62	5	20	11	2.74	10	0.12	0.43	239	2	0.01	6	780	0	67	0.11	51	30
488	0.5	1.66	10	70	0.81	11	36	27	2.82	30	0.17	0.85	444	0	0.01	18	780	2	73	0.19	64	80
489	0.5	2.01	5	50	1.33	13	51	23	4.52	20	0.10	0.93	460	0	0.01	20	1150	0	113	0.19	107	60
490	0.5	1.89	10	70	0.98	10	48	27	3.69	20	0.15	0.81	418	0	0.01	17	1020	0	76	0.15	86	50
492	0.5	1.87	5	40	1.04	9	17	9	3.62	20	0.14	0.71	469	0	0.01	8	800	2	87	0.14	72	50
493	2.0	1.26	5	30	0.76	7	41	10	4.67	20	0.08	0.47	312	0	0.01	10	900	0	61	0.11	112	30
494	0.5	0.82	5	20	0.66	7	28	24	4.52	20	0.05	0.28	183	0	0.06	4	690	0	28	0.10	133	10
495	2.0	1.04	5	30	0.80	10	44	39	8.02	20	0.05	0.34	233	0	0.07	4	660	0	35	0.10	232	20
496	0.5	1.13	5	40	0.73	6	17	18	2.94	30	0.10	0.45	296	0	0.02	6	700	2	51	0.13	77	30
497	0.5	0.80	10	50	0.77	7	65	19	3.42	20	0.09	0.53	213	0	0.01	13	1640	0	65	0.14	99	30
498	0.5	0.50	5	20	0.50	4	30	13	3.22	10	0.06	0.19	141	0	0.03	4	830	0	21	0.08	85	10
522	1.0	1.19	10	150	0.90	7	31	28	3.26	60	0.06	0.39	324	1	0.02	12	890	12	30	0.09	91	56
538	1.0	1.53	15	90	0.69	10	22	31	2.70	60	0.15	0.50	406	1	0.05	10	480	6	34	0.11	78	40
554	1.0	0.82	10	50	0.47	9	17	26	3.05	20	0.14	0.30	172	2	0.05	9	530	2	22	0.07	69	26
565	1.0	2.63	15	170	0.64	17	31	189	3.86	30	0.42	1.27	573	6	0.05	16	760	12	33	0.19	92	92
566	1.0	1.84	25	340	0.90	11	42	49	3.19	50	0.09	0.55	437	1	0.04	22	580	16	43	0.09	70	90
567	1.0	2.21	25	270	0.87	12	50	44	3.24	50	0.10	0.67	434	1	0.03	30	590	18	53	0.08	65	60
579	1.0	0.53	5	30	0.45	4	9	11	1.98	40	0.09	0.19	173	1	0.03	4	410	4	19	0.07	46	16
580	1.0	0.81	5	40	0.47	4	13	14	1.36	30	0.14	0.31	238	1	0.03	4	310	6	30	0.10	26	34
582	1.0	1.35	10	100	0.74	9	14	26	2.72	40	0.23	0.69	560	1	0.03	8	740	6	37	0.14	64	58
583	1.0	1.76	10	90	0.71	12	29	43	2.98	30	0.22	0.82	581	1	0.03	18	760	8	55	0.17	54	74
585	1.0	1.52	5	90	0.98	9	13	32	1.82	20	0.17	0.66	352	1	0.04	8	570	6	84	0.14	45	40
586	1.0	1.86	5	110	0.86	13	14	52	2.81	30	0.22	0.97	639	1	0.04	6	510	4	40	0.16	55	66
592	30.0	2.28	5	100	1.16	12	32	71	2.49	30	0.18	0.95	471	1	0.13	8	470	6	61	0.10	55	80
593	1.0	0.81	5	50	0.62	6	15	38	2.10	20	0.09	0.30	154	1	0.05	5	510	4	26	0.07	56	24
594	1.0	0.30	5	20	0.33	2	8	8	1.43	30	0.06	0.13	111	1	0.01	2	620	1	16	0.03	36	14
595	1.0	0.77	5	70	0.51	5	9	16	1.68	30	0.14	0.31	180	1	0.05	4	520	2	27	0.06	42	22
596	1.0	0.45	5	30	0.29	3	8	6	1.65	20	0.10	0.21	298	1	0.01	3	470	6	13	0.06	21	30
597	1.0	0.35	5	30	0.26	1	3	2	0.69	20	0.10	0.13	178	1	0.01	1	310	4	14	0.06	9	14
598	1.0	0.67	5	30	0.43	5	56	13	2.39	20	0.10	0.37	474	1	0.01	13	560	8	21	0.11	41	58
599	1.0	1.07	5	140	0.50	7	24	19	2.39	20	0.21	0.56	477	1	0.04	14	510	6	28	0.10	42	44
600	1.0	1.12	5	50	0.56	8	18	21	2.25	20	0.12	0.59	526	1	0.03	8	520	8	31	0.12	48	68
602	1.0	0.66	5	50	0.33	5	13	11	1.58	30	0.13	0.31	251	1	0.02	7	390	8	15	0.07	26	24
603	1.0	0.49	5	30	0.29	2	4	6	0.71	20	0.09	0.20	141	1	0.02	2	230	2	15	0.04	12	14
604	2.0	2.03	10	140	0.86	16	32	43	3.28	20	0.22	1.06	618	1	0.07	14	760	12	66	0.17	63	70
605	1.0	2.21	5	110	0.91	18	36	42	3.59	30	0.18	1.25	620	1	0.07	18	660	12	59	0.18	77	70
606	1.0	1.03	5	90	0.60	9	23	21	2.15	30	0.22	0.58	520	1	0.02	15	630	10	37	0.10	32	56
635	1.0	0.72	5	60	0.38	5	12	16	1.52	20	0.19	0.31	200	1	0.03	4	450	4	16	0.08	32	22
636	1.0	1.63	5	70	0.54	10	25	32	2.74	30	0.08	0.53	392	1	0.05	12	470	4	25	0.11	58	42

Notes: All Be, Bi, Cd results are less than or equal to 4 ppm.
All Ga, La results are less than or equal to 30 ppm.
All Tl, U, W results are less than or equal to 15 ppm.
All Au values of 0.5 represent analyses below detection limits.
All As values of 5 represent analyses below detection limits.
All Ni, Mo, Pb values of 0 represent analyses below detection limits.

TABLE A-2
STREAM SEDIMENT DATA FROM VOLCANIC AND SEDIMENTARY LITHOLOGIES

Sample No.	Au ppb	Al %	As ppm	Ba ppm	Ca %	Co ppm	Cr ppm	Cu ppm	Fe %	Hg ppb	K %	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sr ppm	Ti %	V ppm	Zn ppm
102	3.0	2.19	20	30	0.88	26	40	14	8.48	30	0.01	1.03	609	0	0.04	19	390	0	39	0.13	155	60
103	8.0	2.92	230	110	1.69	23	42	37	5.54	80	0.04	1.03	2749	2	0.04	24	730	4	74	0.11	267	60
105	2.0	2.17	10	30	0.87	20	31	20	5.82	60	0.01	1.11	521	1	0.03	18	400	0	39	0.18	117	60
106	2.0	2.43	10	50	1.64	29	22	781	2.59	50	0.06	0.85	279	5	0.14	16	620	0	74	0.14	71	40
107	1.0	2.48	10	140	1.13	20	42	47	4.72	70	0.07	1.06	875	1	0.04	34	700	0	120	0.18	113	80
108	7.0	0.52	70	190	0.35	26	29	27	6.57	400	0.07	0.26	971	1	0.00	70	540	10	31	0.01	50	130
109	0.5	2.51	10	130	1.34	19	44	39	4.70	150	0.09	1.03	836	0	0.05	33	670	6	110	0.21	122	80
110	0.5	3.16	20	50	1.26	23	24	81	5.92	180	0.05	1.43	960	1	0.03	15	590	0	44	0.13	126	70
111	0.5	2.53	20	70	1.10	18	30	56	4.83	140	0.05	1.18	805	0	0.04	17	680	0	37	0.15	117	60
112	0.5	3.01	20	30	1.25	23	20	85	6.05	190	0.04	1.38	970	1	0.02	13	550	0	40	0.11	122	70
113	2.0	3.14	30	50	0.47	23	17	109	6.31	100	0.03	1.14	1207	0	0.01	12	660	0	22	0.04	108	70
114	0.5	3.25	20	30	1.50	24	22	82	6.04	240	0.03	1.34	946	1	0.02	13	530	0	51	0.11	116	60
115	2.0	2.54	30	50	0.82	23	20	104	6.16	460	0.06	1.25	1114	1	0.01	12	610	0	21	0.07	118	70
116	1.0	2.43	20	310	0.74	19	34	43	4.67	210	0.08	0.95	833	0	0.02	32	540	0	58	0.03	93	80
117	0.5	1.70	10	180	0.76	15	36	13	3.97	100	0.08	0.69	627	1	0.03	24	550	0	47	0.10	103	60
118	2.0	2.57	20	280	1.33	17	38	18	3.98	170	0.11	1.13	676	1	0.07	29	730	0	83	0.12	91	70
119	0.5	2.59	20	80	0.81	20	28	68	5.05	90	0.04	1.27	852	1	0.01	18	570	0	35	0.16	122	60
122	1.0	2.88	50	170	1.09	17	27	49	4.62	130	0.04	1.07	836	0	0.01	16	680	0	71	0.14	113	80
123	37.0	1.95	20	320	0.76	13	28	12	3.40	90	0.07	0.70	704	0	0.02	19	500	0	51	0.09	80	70
126	0.5	2.54	10	30	1.66	14	39	84	4.00	60	0.05	0.88	433	2	0.20	14	590	0	90	0.16	126	50
127	2.0	2.96	40	90	1.07	24	39	53	5.68	120	0.06	1.27	925	1	0.04	23	600	0	75	0.12	107	80
128	16.0	1.63	20	50	1.03	10	44	11	2.73	60	0.04	0.80	385	0	0.02	22	410	0	56	0.15	67	40
129	3.0	2.10	30	80	0.71	19	53	29	4.27	70	0.07	1.01	649	1	0.01	43	700	24	41	0.04	66	80
130	2.0	2.11	10	80	1.09	19	56	36	3.93	80	0.07	0.94	731	0	0.01	40	770	4	49	0.02	59	80
131	3.0	2.75	10	60	0.64	27	54	60	5.79	80	0.07	1.25	653	1	0.01	59	880	4	35	0.01	68	120
132	2.0	2.68	50	70	0.91	26	52	46	5.03	140	0.07	1.26	752	1	0.04	50	660	8	63	0.07	76	90
133	3.0	2.99	50	100	1.07	26	40	59	5.95	110	0.06	1.30	983	1	0.04	25	610	30	86	0.12	112	80
134	26.0	2.52	50	50	1.24	17	33	45	4.05	70	0.05	1.11	812	0	0.03	19	680	4	62	0.13	109	70
135	9.0	2.45	30	40	0.68	20	18	81	5.98	70	0.05	1.02	886	0	0.01	13	650	0	32	0.03	102	60
136	4.0	2.80	20	30	0.73	28	20	115	6.47	140	0.03	0.92	739	0	0.01	13	630	0	38	0.01	95	40
137	106	1.73	40	40	0.68	19	13	77	5.65	220	0.04	0.92	889	0	0.02	11	660	0	37	0.04	91	70
138	62.0	1.89	20	30	0.62	20	14	77	5.86	110	0.03	0.95	909	0	0.01	9	580	0	27	0.04	106	60
139	14.0	2.10	20	30	0.79	21	11	79	5.38	130	0.02	1.08	1040	0	0.02	10	570	0	21	0.03	92	60
140	0.5	3.12	10	90	1.09	25	49	50	4.86	60	0.08	1.43	733	0	0.02	54	810	0	109	0.11	88	70
142	2.0	3.22	30	100	1.26	27	58	57	4.74	130	0.08	1.60	786	0	0.03	57	820	0	108	0.14	92	70
143	8.0	3.36	20	80	1.36	32	114	61	5.32	70	0.06	2.38	929	0	0.02	77	770	0	75	0.30	106	80
144	0.5	3.32	20	80	1.05	31	118	59	5.56	60	0.08	2.26	876	0	0.02	77	700	0	52	0.27	103	90
146	0.5	1.97	10	40	1.46	11	44	41	2.58	80	0.02	0.87	490	0	0.02	27	780	4	76	0.13	72	40
147	11.0	3.38	40	60	1.44	29	100	48	5.08	210	0.05	2.56	782	0	0.02	84	770	0	65	0.32	114	70
148	2.0	1.27	10	60	0.87	9	20	18	2.92	50	0.13	0.60	379	0	0.07	9	840	0	36	0.18	71	40
149	5.0	1.25	10	40	0.83	9	15	10	2.83	150	0.06	0.71	576	0	0.03	9	780	0	24	0.15	53	50
150	0.0	1.95	40	100	0.74	11	22	20	2.94	120	0.05	0.68	649	4	0.02	14	650	4	56	0.13	67	50
151	0.5	2.41	50	100	0.88	17	23	34	3.99	60	0.07	1.11	759	1	0.03	17	610	4	39	0.14	71	60
152	0.5	2.03	40	120	0.74	15	22	25	3.91	120	0.08	0.93	853	1	0.02	16	690	4	37	0.07	64	70
153	0.5	1.88	30	140	0.64	14	21	24	3.62	150	0.08	0.84	859	0	0.03	16	610	0	43	0.08	57	60
154	9.0	2.17	10	130	0.79	16	26	32	4.47	390	0.07	0.78	681	0	0.02	16	550	0	43	0.10	75	60
155	0.5	3.25	30	190	1.92	19	28	50	5.46	580	0.08	1.02	894	0	0.03	16	710	0	113	0.14	100	80
156	0.5	2.94	20	250	1.60	22	42	42	5.50	230	0.12	1.27	903	1	0.05	47	790	0	247	0.12	87	80
157	0.5	2.43	20	180	1.41	16	25	29	4.37	120	0.13	0.79	936	0	0.03	18	770	0	145	0.20	80	80
159	2.0	2.74	10	200	1.07	15	32	28	4.31	100	0.11	0.84	895	0	0.03	26	810	4	142	0.16	82	80
160	0.5	2.06	20	170	0.93	16	27	37	4.72	170	0.10	0.85	933	0	0.02	16	860	28	62	0.12	85	70
162	0.5	2.15	20	170	1.05	17	27	30	4.62	340	0.08	0.91	978	0	0.02	22	930	0	97	0.14	87	70
163	0.5	2.45	30	200	1.49	16	23	40	4.47	130	0.11	0.91	1006	0	0.02	16	930	0	88	0.14	82	60
164	3.0	1.75	20	120	0.74	16	27	33	4.37	240	0.09	0.86	821	0	0.02	17	840	0	48	0.09	74	70
165	0.5	2.57	20	200	0.98	21	39	30	4.50	680	0.12	0.95	850	0	0.02	44	720	0	86	0.03	68	70
166	0.5	3.37	10	210	1.39	20	50	37	4.25	130	0.12	1.09	762	0	0.03	53	580	4	114	0.05	76	70
167	0.5	3.41	20	110	1.61	26	48	51	4.56	220	0.14	1.59	750	0	0.04	62	770	0	125	0.07	78	70
168	0.5	4.03	10	70	2.63	24	49	47	4.52	80	0.10	1.68	747	0	0.04	60	1160	0	186	0.20	88	50
169	0.5	3.71	10	70	1.99	26	54	51	4.78	100	0.09	1.93	743	0	0.04	68	1030	0	165	0.21	91	60
170	0.5	4.09	10	80	1.83	31	54	49	5.04	70	0.08	2.41	945	0	0.03	84	1070	0	154	0.17	95	70
171	0.5	3.90	10	50	1.96	33	61	59	5.01	60	0.06	2.87	811	0	0.04	93	690	0	149	0.19	86	70
172	0.5	3.62	10	60	1.62	29	51	51	4.93	60	0.08	1.85	715	0	0.03	65	650	0	96	0.09	86	70
173	0.5	2.83	20	90	0.79	24	48	31	4.62	70	0.08	1.30	678	0	0.02	49	600	0	51	0.07	90	70
176	0.5	3.38	10	150	1.16	26	53	47	5.25	70	0.11	1.36	828	1	0.02	58	710	14	89	0.07	93	150
177	17.0	1.49	10	30	1.27	10	25	20	2.27	50	0.05	0.54	306	0	0.09	10	380	0	54	0.13	63	30
178	6.0	2.03	40	100	0.66	17	19	37	3.44	50	0.09	0.55	709	1	0.02	11	450	8	33	0.02	41	70
179	7.0	3.65	20	140	1.42	21	30	43	4.44	40	0.09	0.97	723	0	0.02	20	530	0	63	0.03	55	70
180	7.0	2.10	20	160	1.22	16	36	36	3.47	120	0.09	1.03	777	0	0.05	21	620	6	47	0.10	61	60
182	5.0	2.40	60	130	1.01	18	19	37	3.82	120	0.08	1.01	741	1	0.05	21	630	4	52	0.11	63	60
183	16.0	2.29	70	150	0.91	21	27	35	4.44	160	0.11	0.98	1065	1	0.06	17	710	4	57	0.12	66	70
184	0.5	2.65	30	160	1.37	17	27	33	3.65	80	0.13	0.95	877	1	0.06	16	910	4	104	0.20	57	60
185	6.0	2.23	20	130	1.00	13	23	29	3.41	60	0.09	0.87	689	1	0.03	12	710	0	52	0.19	61	60
187	2.0	2.32	40	110	0.95	16	20	32	3.94	50	0.08	1.01	859	1	0.05	13	770	4	39	0.19	60	70
188	0.5	1.13	10	40	0.97	8	22	20	2.66	50	0.09	0.56	362	0	0.05	8	730	0	32	0.16	66	30
189	0.5	1.42	10	70	0.73	10	23	32	2.66	70	0.08	0.60	520	1	0.04	9	820	0	33	0.16	70	40
198	6.0	1.89	20	120	0.90	12	25	18	3.41	90	0.07	0.77	933	1	0.02	12	740	0	53	0.17	65	60
199	0.5	2.46	40	90	1.01	14	19	20	3.58	70	0.09	0.85	749	1	0.05	9	680	0	63	0.16	61	60
200	135	1.33	20	30	1.12	14	44	36	5.12	50	0.07	0.42	317	0	0.09	8	570	0	44	0.14	164	30
201	1.0	2.02	30	70	1.07	16	43	33	3.68	100	0.11	1.08	654	0	0.08	20	780	0	60	0.18	96	60
202	1.0	1.33	10	20	1.12	9	24	27	2.67	50	0.07	0.38	274	0	0.10	5	450	0	47	0.12	71	20
204	6.0	2.66	30	50	1.45	19	43	36	3.66	70	0.07	1.36	606	0	0.12	22	770	0	75	0.24	94	50
205	2.0	4.83	50	80	2.47	42	126	89	4.60	100	0.13	2.01	735	0	0.08	76	840	6	102	0.28	103	80
206	2.0	1.03	20	40	0.64	11	40	53	2.98	80	0.18	0.63	327	1	0.02	19	1020	4	21	0.15	95	40
207	7.0	4.00	120	70	1.00	30	129	67	4.84	60	0.09	2.02	502	1	0.04	78	950	4	58	0.16	132	90
208	0.5	0.35	5	20	0.35	3	19	11	1.30	30	0.09	0.19	124	0	0.01	4	720	0	13	0.07	41	10
209	3.0	2.17	40	50	1.13	17	57	39	3.43	70	0.15	1.08	517	2	0.07	27	840	0	55	0.20	90	50
210	0.5	0.35	5	40	0.42	3	26	17	2.63	30	0.05	0.14	134	0	0.01	2	810	0	15	0.07	96	10
211	0.5	0.62	5	30	0.42	4	4	12	1.34	30	0.06	0.33	181	0	0.02	6	610	0	20	0.09	36	20
212	0.5	0.44	5	20	0.35	3	6	14	1.34	110	0.04	0.20	148	0	0.01	3	560	0	14	0.06	36	10
213	3.0	1.19	30	140	0.52	8	7	15	3.04	110	0.09	0.52	914	1	0.02	8	720	0	20	0.09	54	50
214	2.0	1.69	5	70	1.25	16	16	35	5.98	70	0.07	0.78	486	0	0.05	8	920	0	58	0.17	227	50
215	8.0	1.94	5	50	0.99	12	34	29	2.68	30	0.05	0.98	394	0	0.09	20	450	0	57	0.17	64	40
216	30.0	1.65	5	20	1.22	14	54	34	6.33	40	0.04	0.70	386	0	0.06	11	970	0	48	0.22	252	40

TABLE A-2
STREAM SEDIMENT DATA FROM VOLCANIC AND SEDIMENTARY LITHOLOGIES — *Continued*

Sample No.	Au ppb	Al %	As ppm	Ba ppm	Ca %	Co ppm	Cr ppm	Cu ppm	Fe %	Hg ppb	K %	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sr ppm	Ti %	V ppm	Zn ppm
217	2.0	1.69	100	250	1.06	23	24	61	5.89	80	0.19	0.82	842	2	0.06	15	1000	0	65	0.11	133	70
218	0.5	4.32	5	50	2.23	21	14	46	5.64	190	0.03	1.42	949	0	0.02	16	510	0	109	0.16	120	70
222	2.0	4.02	5	40	2.48	20	14	55	4.84	50	0.02	1.35	[illegible]	0	0.03	13	570	0	108	0.16	103	70
223	0.5	4.35	5	40	2.46	21	12	58	4.92	60	0.03	1.33	886	0	0.03	11	480	0	96	0.13	98	60
225	4.0	3.81	5	60	1.77	17	13	45	4.89	160	0.02	1.00	998	0	0.02	13	700	0	56	0.16	125	100
226	3.0	3.53	5	40	1.86	21	17	45	5.82	100	0.01	1.35	884	0	0.03	14	620	0	72	0.21	152	60
227	0.5	4.64	5	50	2.53	24	14	64	6.00	60	0.03	1.68	1106	0	0.02	14	650	0	89	0.22	143	70
228	0.5	3.67	5	50	1.70	21	18	46	5.85	80	0.02	1.37	939	0	0.02	16	560	0	79	0.18	143	70
229	0.5	5.72	5	30	3.44	22	11	23	4.97	30	0.01	1.69	922	0	0.01	12	550	0	86	0.20	131	60
230	0.5	3.32	5	40	1.91	16	9	21	4.06	100	0.01	1.07	826	0	0.01	13	660	0	75	0.09	82	60
231	7.0	4.88	5	50	2.92	19	11	38	4.65	90	0.06	1.46	1022	0	0.02	13	760	0	107	0.15	104	60
233	0.5	3.23	5	90	1.34	21	20	51	5.17	420	0.07	1.12	1079	0	0.02	23	620	0	91	0.10	97	90
234	15.0	3.33	5	120	1.17	23	15	59	5.47	280	0.08	1.24	1490	0	0.02	23	650	0	74	0.10	101	90
235	2.0	3.53	10	50	1.83	22	22	62	5.92	190	0.04	1.44	1016	0	0.02	18	530	0	62	0.17	185	70
236	7.0	3.33	10	50	1.68	21	18	72	6.12	250	0.06	1.38	1027	0	0.02	15	680	0	55	0.15	160	80
237	0.5	3.94	5	50	1.94	23	20	53	5.81	100	0.07	1.49	1033	0	0.03	16	640	0	79	0.15	130	80
238	26.0	3.03	5	90	0.86	22	62	42	4.63	70	0.08	1.39	675	0	0.03	54	750	4	86	0.14	94	80
239	2.0	2.56	10	90	0.46	25	41	51	5.84	200	0.10	1.09	583	0	0.02	61	880	8	37	0.00	71	110
240	1.0	3.49	5	40	2.18	21	55	39	4.40	70	0.03	1.90	689	0	0.02	47	870	0	62	0.27	121	60
242	0.5	2.42	10	70	0.47	24	40	47	5.60	200	0.06	1.09	605	0	0.01	57	870	6	35	0.00	71	110
243	0.5	3.23	5	100	0.71	23	60	43	4.86	100	0.05	1.44	792	0	0.01	57	840	0	65	0.08	99	90
244	0.5	3.32	5	80	2.01	20	36	36	4.05	80	0.01	1.84	662	0	0.02	53	810	0	107	0.21	95	60
245	0.5	3.09	5	40	2.50	21	51	45	4.29	50	0.02	1.72	619	0	0.06	46	900	0	97	0.43	130	50
247	0.5	3.83	5	130	1.78	27	60	50	4.83	180	0.07	1.80	724	0	0.04	60	750	4	153	0.18	105	80
248	0.5	3.26	5	40	2.72	21	53	45	4.28	60	0.03	1.76	628	0	0.07	47	860	0	103	0.39	127	60
249	2.0	3.26	5	120	0.82	20	46	36	4.49	60	0.11	1.15	561	0	0.02	46	680	0	82	0.03	81	90
250	1.0	3.31	5	130	0.68	22	48	41	4.69	80	0.15	1.21	572	0	0.03	51	650	0	70	0.02	82	90
251	1.0	3.54	50	120	1.05	29	36	47	5.54	580	0.08	1.11	953	0	0.04	39	660	4	110	0.04	85	90
252	2.0	3.63	10	60	1.60	17	64	21	4.15	80	0.02	1.51	545	0	0.10	29	790	0	103	0.18	165	70
253	2.0	3.49	10	70	1.64	17	48	22	4.07	80	0.02	1.34	813	0	0.09	26	650	0	112	0.18	160	70
254	3.0	3.78	5	80	1.10	19	35	36	4.06	60	0.04	1.30	511	0	0.04	35	1010	0	96	0.15	146	70
255	0.5	3.34	5	90	0.97	19	48	28	4.06	80	0.09	1.26	527	0	0.02	47	660	0	77	0.12	83	90
256	0.5	4.26	5	100	1.41	20	39	24	4.06	100	0.07	1.32	773	0	0.04	29	710	0	102	0.16	105	80
257	0.5	3.46	5	80	1.43	19	30	39	4.64	80	0.08	1.36	759	0	0.05	24	660	0	137	0.24	110	70
258	0.5	3.45	5	100	1.29	25	52	50	5.07	130	0.11	1.50	765	0	0.04	53	680	0	108	0.10	104	90
259	0.5	4.01	5	70	1.74	22	26	44	4.95	90	0.05	1.53	905	0	0.04	23	560	0	122	0.21	135	70
262	0.5	5.19	5	110	1.51	27	29	52	5.81	70	0.05	1.63	1146	0	0.06	22	460	0	110	0.10	151	70
264	2.0	2.61	30	50	0.79	19	49	41	4.50	70	0.04	1.41	557	0	0.05	44	790	0	45	0.13	79	70
265	1.0	2.34	5	60	1.22	19	53	34	4.18	60	0.04	1.40	546	0	0.05	53	750	0	47	0.13	71	70
266	0.5	4.09	5	30	2.64	21	8	64	5.89	40	0.01	1.33	1009	0	0.01	11	610	0	80	0.23	126	80
267	1.0	4.43	5	30	2.60	22	17	68	5.92	30	0.03	1.39	948	0	0.04	13	540	0	84	0.19	135	70
269	0.5	3.50	5	40	1.57	24	16	61	6.43	30	0.01	1.59	975	0	0.02	14	460	0	59	0.14	132	70
270	17.0	3.64	20	60	1.34	22	20	100	5.75	80	0.04	1.37	1341	0	0.04	16	650	0	74	0.16	136	70
271	0.5	3.51	5	30	1.66	23	18	54	5.60	30	0.00	1.75	883	0	0.02	15	460	0	57	0.16	131	70
272	3.0	3.78	10	60	1.07	20	20	63	5.54	50	0.04	1.27	735	0	0.01	19	710	0	53	0.06	124	80
273	2.0	3.83	5	30	1.96	22	26	53	6.06	40	0.02	1.57	888	0	0.03	22	600	0	68	0.19	141	70
274	1.0	3.63	5	30	1.55	22	14	62	6.46	30	0.02	1.52	905	0	0.03	15	520	0	60	0.15	142	60
275	1.0	3.79	5	20	1.93	20	10	51	5.72	30	0.00	1.29	897	0	0.02	9	440	0	73	0.13	119	50
276	0.5	3.11	5	20	1.68	21	7	45	5.79	30	0.00	1.30	947	0	0.01	11	530	0	41	0.09	108	60
277	1.0	3.10	5	20	1.33	21	9	51	5.46	240	0.00	1.20	824	0	0.01	9	570	0	49	0.06	108	50
278	4.0	2.76	5	40	0.52	20	15	110	6.10	190	0.06	1.15	684	2	0.02	10	630	0	28	0.03	110	50
279	4.0	3.22	5	50	0.82	22	16	99	5.64	210	0.06	1.52	1015	1	0.01	13	630	0	28	0.07	117	60
280	3.0	3.91	5	30	1.49	23	14	54	6.83	150	0.01	1.30	709	0	0.02	10	580	0	53	0.08	130	60
282	0.5	3.09	5	50	1.02	25	32	95	7.53	160	0.04	1.57	939	1	0.03	16	650	0	37	0.15	186	70
283	1.0	2.92	5	60	1.40	19	23	40	5.15	100	0.04	1.25	552	0	0.04	20	740	0	62	0.16	116	70
284	1.0	2.88	5	50	1.35	21	33	51	5.43	110	0.04	1.45	770	0	0.05	30	680	0	51	0.18	122	70
285	0.5	3.71	5	50	1.98	21	15	47	5.69	140	0.02	1.38	849	0	0.03	13	580	0	85	0.21	140	70
286	0.5	4.94	5	40	2.85	22	14	51	5.77	70	0.01	1.69	965	0	0.02	12	570	0	75	0.23	166	60
287	0.5	4.17	5	50	2.43	21	15	55	6.01	120	0.04	1.43	1034	0	0.02	16	710	0	89	0.21	146	80
288	0.5	3.37	5	70	1.61	20	14	56	5.59	150	0.05	1.23	976	0	0.02	19	590	0	62	0.12	117	70
289	2.0	4.20	10	40	2.60	20	8	53	4.84	240	0.04	1.32	948	0	0.01	10	660	4	86	0.18	102	70
290	48.0	3.52	5	40	2.14	22	27	60	5.20	220	0.01	1.63	1002	0	0.04	18	650	0	84	0.16	118	80
291	2.0	2.84	5	90	1.44	18	50	45	4.72	90	0.06	1.42	654	0	0.05	48	760	0	91	0.20	106	70
292	0.5	4.97	5	90	1.97	22	33	52	5.10	110	0.07	1.45	895	0	0.02	22	640	0	152	0.22	124	70
293	0.5	5.39	5	100	2.87	22	30	64	5.14	80	0.07	1.49	776	0	0.07	25	390	0	196	0.13	129	60
295	2.0	3.31	5	110	1.16	29	78	64	5.51	70	0.10	1.92	831	0	0.08	76	650	8	83	0.19	120	80
296	0.5	3.70	5	120	1.59	19	33	53	4.76	60	0.09	1.36	832	0	0.02	33	700	0	133	0.18	96	80
297	4.0	4.34	70	100	1.67	28	50	376	5.21	60	0.08	1.37	881	0	0.02	39	880	14	121	0.23	115	140
298	3.0	4.37	40	150	1.79	32	44	95	5.29	90	0.10	1.31	958	0	0.02	54	620	30	131	0.06	81	150
300	0.5	3.31	5	70	1.28	15	25	48	6.41	60	0.05	1.00	838	0	0.03	13	690	0	84	0.30	166	80
302	0.5	2.47	10	230	0.65	14	31	31	3.64	60	0.13	0.65	667	0	0.02	29	470	4	63	0.03	51	70
303	7.0	2.08	10	120	0.71	15	29	21	3.71	70	0.06	0.56	649	0	0.01	26	560	4	56	0.01	39	70
304	0.5	3.15	10	360	0.86	20	78	27	4.39	90	0.11	1.33	860	0	0.01	112	510	0	83	0.04	79	90
305	0.5	3.07	20	320	0.81	17	41	32	4.04	80	0.15	0.83	718	0	0.02	45	350	4	112	0.01	56	80
306	0.5	3.58	30	110	1.80	22	51	40	4.50	170	0.11	1.61	812	0	0.04	56	750	0	154	0.19	104	60
308	0.5	4.89	10	30	3.43	20	42	38	4.18	50	0.05	1.83	692	0	0.07	55	1150	0	241	0.38	101	50
309	0.5	3.80	10	110	2.29	22	49	47	4.80	40	0.08	1.43	781	0	0.03	58	1020	0	170	0.19	86	60
310	2.0	2.96	20	150	1.14	26	43	52	4.60	100	0.11	1.10	985	0	0.02	49	720	6	96	0.06	81	80
311	0.5	3.44	20	130	1.25	37	41	56	5.79	120	0.13	1.13	1582	0	0.02	48	760	8	113	0.01	77	100
312	0.5	3.79	10	30	2.95	20	34	38	4.29	20	0.02	2.02	666	0	0.04	54	1140	0	139	0.42	109	50
313	0.5	3.97	20	120	2.00	24	40	52	5.14	40	0.08	1.64	741	0	0.02	55	870	0	142	0.10	91	80
314	0.5	3.52	10	90	1.29	22	62	43	4.89	50	0.08	1.83	755	0	0.02	56	840	0	88	0.20	107	70
315	0.5	3.44	20	120	1.24	24	43	39	4.75	60	0.12	1.49	746	0	0.02	48	600	4	111	0.08	80	80
316	15.0	4.42	20	140	1.75	29	63	67	5.81	40	0.08	2.32	922	0	0.02	62	670	0	113	0.20	136	80
317	0.5	3.54	10	90	1.57	22	56	44	4.85	50	0.07	1.81	714	0	0.04	56	730	0	108	0.21	109	70
318	1.0	2.62	10	130	1.21	18	40	31	3.87	60	0.08	1.06	663	0	0.03	42	660	0	92	0.10	71	70
320	0.5	5.07	20	90	2.34	24	27	64	6.14	80	0.11	1.20	928	0	0.09	14	400	0	127	0.05	146	70
322	0.5	4.61	20	70	2.33	25	49	55	7.24	250	0.07	1.60	1039	0	0.14	18	400	0	120	0.12	214	80
323	0.5	4.62	20	30	2.98	16	14	38	5.25	160	0.04	1.45	1034	0	0.04	7	810	0	196	0.25	118	80
324	0.5	5.28	10	260	3.23	14	13	31	4.84	80	0.03	1.13	828	0	0.02	8	780	0	196	0.26	117	70
325	2.0	3.18	20	120	1.08	28	49	46	5.22	100	0.09	1.34	934	0	0.02	54	730	4	92	0.08	95	90
326	2.0	3.53	10	120	1.14	23	45	45	5.64	60	0.08	1.45	795	0	0.03	42	690	4	97	0.20	126	80
327	0.5	3.70	80	140	1.17	25	59	38	6.10	6100	0.09	1.75	1091	0	0.02	31	690	0	77	0.14	119	90
328	0.5	3.25	5	30	1.86	16	11	33	4.13	50	0.03	1.44	740	0	0.00	6	700	0	170	0.30	91	70

TABLE A-2
STREAM SEDIMENT DATA FROM VOLCANIC AND SEDIMENTARY LITHOLOGIES — *Continued*

Sample No.	Au ppb	Al %	As ppm	Ba ppm	Ca %	Co ppm	Cr ppm	Cu ppm	Fe %	Hg ppb	K %	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sr ppm	Ti %	V ppm	Zn ppm
329	0.5	5.15	10	30	3.65	18	12	40	4.99	50	0.04	1.51	1066	0	0.05	6	890	0	165	0.27	114	80
330	0.5	4.94	10	40	3.31	17	23	43	7.10	40	0.05	1.37	1096	0	0.03	8	810	0	164	0.28	178	90
331	6.0	2.84	170	180	1.16	23	50	27	6.12	60	0.06	0.91	1551	0	0.02	35	780	0	79	0.01	60	100
332	1.0	1.55	10	70	0.95	8	13	10	3.08	50	0.05	0.74	682	0	0.04	9	710	0	32	0.21	53	50
333	5.0	2.77	50	190	0.76	17	15	32	4.59	360	0.09	1.00	1120	0	0.01	12	690	50	46	0.16	65	90
334	5.0	2.39	20	140	0.64	26	37	117	5.89	460	0.10	0.89	760	6	0.03	33	730	11	59	0.04	62	70
335	4.0	2.49	20	130	0.71	21	46	50	5.26	100	0.07	0.80	844	0	0.03	37	680	4	62	0.03	61	70
338	0.5	2.16	20	100	1.03	17	25	32	4.38	50	0.06	1.13	909	0	0.03	16	790	6	42	0.23	66	70
339	3.0	2.50	30	140	0.47	29	42	58	6.73	50	0.07	1.22	1258	0	0.02	34	1160	10	38	0.13	72	90
340	0.5	1.96	20	90	0.74	13	25	25	3.75	50	0.06	1.05	653	1	0.04	18	910	0	43	0.16	68	60
342	4.0	1.32	10	60	0.89	12	31	28	3.98	50	0.11	0.65	391	0	0.08	11	890	0	47	0.21	95	40
343	2.0	1.42	20	70	0.93	13	32	28	4.16	40	0.12	0.68	375	0	0.09	11	790	0	48	0.18	102	40
344	0.5	3.04	20	140	0.71	24	43	39	5.84	50	0.06	0.83	852	0	0.02	38	520	4	73	0.01	60	90
345	0.5	3.19	40	160	0.88	29	85	39	7.54	50	0.06	1.36	1069	0	0.05	62	890	4	67	0.08	95	110
346	2.0	2.68	10	160	0.74	17	64	28	4.19	60	0.09	1.16	702	0	0.02	87	480	6	53	0.04	73	80
347	0.5	3.67	20	150	1.93	22	54	47	4.92	70	0.08	1.61	797	0	0.03	58	880	0	175	0.20	98	70
378	0.5	3.34	20	50	1.20	30	84	38	7.75	30	0.06	1.09	816	0	0.04	54	870	0	61	0.04	124	90
379	0.5	3.26	5	60	1.26	23	55	35	6.52	20	0.03	1.86	962	0	0.06	36	650	0	57	0.24	101	90
380	0.5	1.73	30	130	0.92	9	43	13	4.10	110	0.07	0.75	608	1	0.04	13	850	0	54	0.15	114	50
382	0.5	2.94	5	110	0.83	20	46	36	5.01	40	0.09	1.26	892	0	0.03	46	700	6	90	0.09	83	100
383	0.5	4.40	5	110	1.19	22	37	64	4.75	60	0.07	1.96	756	0	0.04	27	1350	0	119	0.25	133	90
384	6.0	4.63	5	160	1.93	21	40	67	5.04	1100	0.09	1.79	986	0	0.07	22	1420	0	185	0.30	146	90
385	0.5	2.16	5	90	0.71	16	77	41	8.04	60	0.06	0.95	1030	0	0.03	22	1140	0	107	0.40	287	180
387	2.0	3.51	90	100	0.89	18	37	36	4.29	90	0.12	1.02	662	0	0.08	26	770	8	61	0.15	95	90
388	2.0	3.23	30	90	1.55	19	31	29	3.95	50	0.20	1.11	606	0	0.12	22	770	10	88	0.18	88	90
389	0.5	1.51	5	40	0.96	8	23	13	2.85	160	0.05	0.73	404	0	0.07	10	540	0	36	0.15	56	40
390	0.5	2.79	10	80	1.25	19	62	36	4.24	40	0.05	1.82	711	0	0.06	35	760	0	53	0.26	95	60
392	0.5	3.57	5	110	1.99	18	41	51	5.58	50	0.12	1.15	862	0	0.07	21	1120	0	202	0.44	188	100
393	0.5	4.13	5	80	1.75	20	49	52	5.44	50	0.08	1.30	883	0	0.05	30	1040	0	176	0.34	176	90
394	0.5	4.20	5	120	2.20	23	61	50	5.16	210	0.08	1.52	1135	0	0.09	48	980	0	216	0.34	161	80
395	4.0	3.35	5	100	1.33	18	57	36	5.05	260	0.08	1.27	865	0	0.03	35	1000	0	134	0.22	137	90
396	1.0	4.22	5	60	2.41	16	40	42	4.60	70	0.06	1.38	750	0	0.04	21	1110	0	192	0.29	143	70
397	0.5	3.27	5	80	1.53	21	66	65	7.14	460	0.08	1.52	975	0	0.06	25	1240	0	136	0.39	244	100
398	1.0	4.04	5	100	1.86	20	42	55	5.67	80	0.09	1.53	879	0	0.06	20	1270	0	204	0.35	193	90
399	2.0	3.20	5	110	0.80	23	55	41	5.89	50	0.11	1.38	916	0	0.03	54	710	0	80	0.11	101	110
400	2.0	2.90	5	120	0.52	21	48	37	5.37	40	0.10	1.22	971	0	0.02	56	690	0	35	0.01	72	110
402	2.0	3.36	5	80	1.27	22	51	52	5.95	50	0.07	1.63	1042	0	0.03	41	890	0	149	0.21	138	100
403	2.0	3.00	5	110	0.66	21	47	38	5.44	50	0.08	1.20	864	0	0.01	55	530	2	60	0.04	64	110
404	85.0	1.32	20	220	0.40	17	31	25	5.04	450	0.08	0.44	2338	0	0.01	45	680	12	65	0.01	54	130
405	0.5	2.53	20	200	0.52	20	42	43	5.26	240	0.10	0.98	975	1	0.01	55	630	4	71	0.01	63	120
406	0.5	2.99	5	100	1.01	19	49	33	5.33	60	0.09	1.31	892	0	0.04	41	750	0	98	0.17	113	90
407	2.0	3.82	20	160	1.12	24	40	56	6.44	450	0.16	1.51	1143	0	0.03	31	670	0	72	0.05	146	100
408	2.0	3.17	5	60	1.78	16	93	39	7.59	90	0.08	1.02	1105	1	0.04	29	1410	0	188	0.57	295	160
409	0.5	2.10	5	70	1.24	17	134	49	9.62	50	0.05	0.94	1472	1	0.05	37	1410	0	146	0.71	407	200
410	16.0	3.98	5	50	2.52	12	30	26	7.29	40	0.08	0.91	1237	0	0.07	9	1360	0	227	0.51	266	140
411	6.0	2.76	5	80	1.48	15	80	37	5.31	40	0.08	1.19	827	1	0.05	31	1230	0	197	0.41	195	110
413	0.5	2.83	5	90	1.58	16	60	37	5.29	40	0.09	1.12	825	0	0.06	25	1260	0	203	0.42	193	100
415	0.5	2.30	5	60	1.45	14	97	36	6.30	40	0.07	1.02	844	0	0.05	31	1280	0	183	0.46	248	130
416	0.5	3.70	5	70	2.26	15	43	42	8.14	50	0.10	1.13	1319	0	0.05	15	1400	0	237	0.51	267	160
417	4.0	1.73	5	70	1.02	13	102	34	6.06	40	0.06	0.76	815	0	0.06	27	980	0	193	0.39	231	110
418	0.5	2.27	5	100	1.49	16	107	40	8.10	30	0.06	1.00	1161	1	0.06	33	1250	0	225	0.57	320	160
419	0.5	2.22	5	90	1.35	15	91	39	6.07	30	0.06	1.09	838	1	0.06	34	1220	0	178	0.41	223	110
420	0.5	4.06	5	70	2.27	13	28	22	7.12	40	0.10	0.94	1280	0	0.05	9	1430	0	230	0.54	259	140
422	7.0	1.84	5	80	0.85	15	41	36	6.88	40	0.08	0.81	1017	1	0.07	15	940	0	149	0.42	264	140
423	0.5	1.63	5	70	1.06	15	242	40	9.77	60	0.05	0.71	1164	1	0.06	44	1140	0	190	0.53	368	180
424	0.5	1.87	5	60	0.85	16	67	43	6.80	30	0.07	0.90	882	0	0.07	19	980	0	153	0.40	253	130
425	0.5	1.80	5	60	0.91	13	65	31	6.23	20	0.05	0.75	830	0	0.05	18	980	0	208	0.37	217	110
426	0.5	2.13	5	60	0.88	15	39	38	4.90	30	0.07	1.02	728	0	0.04	16	960	0	124	0.31	169	90
427	0.5	3.12	5	70	1.46	11	54	24	3.96	40	0.07	0.80	673	1	0.04	18	1390	2	146	0.26	124	70
428	0.5	5.00	5	60	3.85	19	29	58	4.18	210	0.06	1.61	718	0	0.07	20	1030	0	347	0.30	153	60
430	0.5	2.86	5	60	2.28	16	71	46	5.45	80	0.03	1.40	650	0	0.10	26	1090	0	172	0.39	197	60
431	8.0	2.88	5	110	1.36	22	68	82	5.10	310	0.07	1.59	1202	0	0.06	32	1350	0	132	0.19	140	90
432	11.0	4.01	5	50	2.22	43	52	782	6.21	170	0.12	1.53	601	18	0.07	24	1380	0	198	0.29	138	40
433	0.5	3.58	5	110	0.77	16	37	53	4.84	90	0.03	1.23	642	0	0.02	19	960	0	81	0.22	153	70
434	4.0	3.31	5	150	1.46	20	57	97	5.79	110	0.08	1.47	851	1	0.06	24	1390	0	133	0.29	184	70
435	1.0	3.00	5	130	1.22	14	24	24	5.57	60	0.10	1.15	927	0	0.04	10	1190	2	178	0.26	173	100
436	2.0	3.27	5	150	1.82	15	32	28	5.91	60	0.10	1.18	995	1	0.05	14	1430	8	214	0.29	179	100
438	0.5	4.09	5	70	2.40	12	27	21	6.32	40	0.09	0.93	968	0	0.05	8	1390	0	231	0.43	209	110
439	0.5	3.70	5	60	2.09	14	29	36	6.93	30	0.09	1.07	1035	0	0.06	10	1200	0	203	0.44	249	130
440	0.5	4.58	5	60	2.61	11	24	20	5.60	20	0.09	0.92	1052	0	0.08	8	1290	0	230	0.41	176	120
442	0.5	4.54	5	50	2.76	12	20	22	5.31	20	0.11	0.94	982	0	0.09	7	1290	4	231	0.40	171	110
443	0.5	4.36	5	60	2.62	14	27	29	6.73	40	0.09	1.04	1178	0	0.07	9	1410	0	221	0.49	237	130
444	0.5	3.40	5	60	1.74	14	86	33	6.25	30	0.09	0.91	842	0	0.05	22	960	0	222	0.35	208	110
445	1.0	2.10	5	50	1.11	18	80	50	10.80	40	0.07	0.91	1483	1	0.04	23	1090	0	165	0.67	431	200
446	0.5	2.47	10	80	1.12	18	30	45	5.65	40	0.10	1.03	981	0	0.06	15	1040	0	197	0.37	197	110
447	2.0	3.25	5	120	1.51	17	44	53	5.44	50	0.12	1.07	999	0	0.03	18	1410	0	222	0.32	194	110
448	0.5	3.07	5	100	1.50	14	35	39	3.45	40	0.11	1.03	709	0	0.04	18	1020	0	245	0.26	105	70
449	0.5	3.04	5	60	1.89	15	74	26	3.87	120	0.07	1.42	592	0	0.05	37	990	0	212	0.33	113	70
450	0.5	2.75	5	110	1.48	15	63	35	5.29	60	0.12	0.97	806	0	0.04	24	1030	0	182	0.41	174	100
452	4.0	1.94	5	60	1.15	15	96	26	4.68	70	0.06	1.18	634	0	0.04	38	870	0	172	0.37	148	80
453	0.5	2.59	5	90	1.18	15	69	36	5.50	40	0.06	0.96	800	1	0.04	24	970	0	149	0.36	187	90
454	0.5	1.88	5	70	0.74	15	69	37	5.50	30	0.06	0.95	754	1	0.05	22	850	0	159	0.35	195	100
456	0.5	1.84	5	50	0.65	16	103	39	6.99	20	0.04	0.95	869	1	0.04	27	880	0	114	0.39	254	120
457	0.5	1.59	5	50	0.93	15	87	36	7.80	30	0.05	0.79	955	1	0.04	22	960	0	163	0.45	280	130
458	0.5	2.47	5	100	1.37	14	73	33	5.88	30	0.07	0.96	896	0	0.06	26	1270	0	257	0.46	223	130
459	1.0	2.42	5	120	1.21	15	78	30	5.57	20	0.08	1.16	901	0	0.07	32	1420	0	232	0.45	198	120
460	0.5	2.77	5	140	1.82	17	50	43	5.35	20	0.12	1.13	869	0	0.08	22	1160	0	269	0.51	191	100
463	0.5	2.59	5	110	1.34	18	78	57	7.68	30	0.10	0.97	1247	1	0.06	26	1360	0	168	0.59	313	170
464	0.5	2.72	5	100	1.34	17	71	36	5.82	30	0.09	1.25	956	0	0.07	28	1300	0	214	0.47	220	120
465	0.5	2.01	5	50	0.93	16	127	39	8.34	20	0.05	1.09	1169	0	0.04	36	1580	0	119	0.61	328	180
466	0.5	3.02	5	180	1.48	20	27	75	6.01	50	0.15	0.87	835	0	0.07	13	1590	0	214	0.34	225	120
467	1.0	2.70	5	130	1.52	19	30	60	5.68	30	0.13	0.96	936	0	0.08	14	1260	0	187	0.51	211	110
468	2.0	2.92	5	110	1.18	16	63	36	5.59	30	0.08	1.10	896	0	0.06	26	1170	0	183	0.44	213	110
469	0.5	2.65	5	100	1.22	15	79	29	5.78	40	0.09	1.18	946	0	0.08	30	1170	0	212	0.47	223	120

TABLE A-2
STREAM SEDIMENT DATA FROM VOLCANIC AND SEDIMENTARY LITHOLOGIES — *Continued*

Sample No.	Au ppb	Al %	As ppm	Ba ppm	Ca %	Co ppm	Cr ppm	Cu ppm	Fe %	Hg ppb	K %	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sr ppm	Ti %	V ppm	Zn ppm
470	0.5	3.00	5	90	1.21	17	86	29	6.33	20	0.07	1.32	1065	0	0.08	33	1130	0	192	0.52	246	120
471	5.0	3.37	5	150	1.59	16	29	52	4.72	40	0.12	0.98	771	0	0.05	16	1460	0	188	0.32	155	80
472	3.0	2.49	5	140	1.33	15	60	46	4.94	40	0.11	0.98	698	0	0.08	25	1110	0	180	0.31	159	100
473	2.0	4.33	5	100	1.90	14	39	34	3.88	50	0.12	1.18	748	0	0.04	23	1490	2	240	0.33	115	90
474	0.5	2.24	5	80	1.31	16	112	35	6.65	30	0.05	1.19	925	0	0.05	34	1280	0	177	0.44	246	120
475	6.0	2.29	5	70	1.23	14	80	25	5.85	30	0.04	1.08	852	0	0.04	28	1190	0	166	0.40	206	110
477	2.0	2.28	5	110	1.35	15	66	44	5.81	40	0.07	0.95	791	0	0.07	25	1180	0	174	0.37	199	100
478	0.5	2.21	5	70	1.11	16	97	32	6.11	60	0.06	1.13	918	0	0.04	36	1190	0	183	0.45	220	130
479	0.5	2.42	5	70	1.31	15	108	29	5.74	40	0.06	1.17	817	0	0.04	38	1210	0	170	0.43	215	110
480	2.0	2.59	5	90	1.16	15	63	39	5.00	30	0.09	1.20	792	0	0.04	28	1120	0	216	0.39	171	100
482	0.5	3.48	5	90	1.60	15	31	34	5.27	30	0.11	1.12	897	0	0.04	15	1240	0	217	0.35	166	110
483	0.5	2.50	5	140	0.74	16	34	32	6.37	60	0.09	1.17	992	0	0.02	12	1390	0	85	0.13	165	100
502	2.0	2.64	10	50	0.69	22	75	33	5.23	40	0.05	1.53	760	0	0.01	56	770	6	35	0.21	98	80
503	12.0	2.33	10	40	0.61	20	47	44	4.26	20	0.06	1.19	582	0	0.02	46	1130	6	71	0.15	68	80
504	15.0	2.29	30	60	0.61	19	43	53	4.57	70	0.07	1.18	729	0	0.02	37	910	6	43	0.15	74	80
505	8.0	2.04	20	50	0.76	16	30	45	4.05	30	0.06	0.97	596	0	0.04	24	850	10	64	0.17	67	70
506	850.0	1.33	20	80	0.65	13	19	64	4.04	50	0.10	0.72	753	4	0.01	11	750	42	73	0.10	63	60
507	15.0	1.24	5	30	0.60	6	8	6	2.08	30	0.07	0.50	357	1	0.01	6	590	2	43	0.10	42	40
508	5.0	3.29	60	70	1.59	18	36	39	4.43	80	0.09	1.47	778	0	0.04	27	760	4	103	0.14	79	80
510	10.0	2.80	40	60	0.26	39	56	77	6.70	70	0.03	1.33	989	1	0.01	77	850	10	17	0.01	61	140
511	55.0	1.91	10	80	0.90	11	31	36	3.59	60	0.07	0.87	557	0	0.04	18	830	4	55	0.17	91	100
512	5.0	3.22	5	90	1.66	15	44	33	4.83	50	0.08	1.08	830	0	0.06	22	960	0	149	0.37	166	90
513	0.5	2.67	5	140	1.26	12	40	29	3.50	80	0.09	0.82	721	0	0.02	31	630	2	68	0.08	77	90
514	0.5	3.19	20	70	1.28	18	35	50	5.49	100	0.05	1.46	836	0	0.05	25	700	0	60	0.19	120	70
515	0.5	3.09	10	120	0.89	18	35	29	5.19	60	0.07	1.18	788	0	0.02	31	600	4	70	0.01	88	90
516	0.5	2.54	60	150	1.83	12	41	22	3.41	60	0.05	0.83	645	1	0.04	20	830	2	170	0.13	86	60
517	6.0	2.65	10	90	1.16	14	42	161	4.90	40	0.06	0.91	537	3	0.16	15	470	0	98	0.19	148	40
523	1.0	2.90	25	100	0.83	11	25	34	3.06	50	0.08	0.61	512	1	0.05	14	720	8	43	0.13	75	36
524	1.0	2.19	15	60	1.15	12	51	40	3.59	20	0.10	0.60	324	1	0.18	15	560	6	68	0.11	101	36
525	1.0	1.85	150	50	1.02	9	23	24	2.60	40	0.04	0.51	390	1	0.03	11	400	1	44	0.11	67	38
526	1.0	2.68	30	90	1.06	18	27	43	4.67	240	0.94	1.05	727	1	0.03	23	520	6	51	0.14	90	72
527	1.0	3.42	25	140	1.84	17	24	41	4.31	320	0.08	1.26	912	1	0.05	17	520	10	91	0.24	90	72
528	1.0	3.73	10	100	2.38	16	22	38	3.85	360	0.08	1.20	676	1	0.04	14	510	12	107	0.18	95	68
529	1.0	2.67	25	190	1.50	16	37	38	4.06	240	0.12	1.02	811	1	0.08	17	480	12	75	0.19	118	86
530	1.0	1.65	20	70	2.08	8	35	34	2.70	70	0.03	0.56	415	1	0.05	12	450	10	74	0.13	90	36
532	1.0	2.90	15	120	1.80	15	35	37	4.01	40	0.10	1.03	638	1	0.06	22	550	4	80	0.21	104	62
533	1.0	2.35	40	100	0.69	15	41	38	4.24	20	0.09	0.73	736	1	0.05	29	460	8	35	0.11	61	82
535	1.0	2.29	30	100	0.62	14	36	32	3.90	30	0.07	0.70	617	1	0.03	28	370	10	29	0.10	51	76
536	1.0	3.87	20	130	2.42	17	26	41	4.39	410	0.08	1.24	743	1	0.04	14	560	4	113	0.21	114	76
537	1.0	3.05	15	80	1.83	19	28	48	4.64	80	0.05	1.32	701	1	0.04	18	440	6	67	0.27	139	66
539	1.0	1.88	20	120	0.82	11	39	30	4.28	80	0.06	0.56	421	1	0.03	23	360	4	75	0.10	106	64
540	1.0	3.40	20	150	2.29	17	22	35	4.10	70	0.05	1.25	1225	1	0.04	13	500	4	113	0.23	108	62
542	1.0	2.40	30	70	0.45	20	36	58	5.26	50	0.04	0.92	819	1	0.02	28	480	8	28	0.04	84	80
543	1.0	2.67	15	80	1.35	18	29	50	5.20	40	0.05	0.99	729	1	0.03	22	630	2	56	0.15	98	72
544	2.0	3.16	5	240	0.97	17	44	42	4.39	70	0.07	0.86	584	1	0.04	46	280	6	98	0.04	81	84
545	2.0	2.60	5	140	1.27	15	34	37	3.79	40	0.10	0.87	620	1	0.04	27	410	12	70	0.11	77	70
546	1.0	2.54	35	60	0.63	21	30	56	4.95	40	0.07	0.58	846	1	0.03	32	440	8	29	0.01	47	106
547	1.0	2.18	35	190	0.94	11	24	28	3.40	50	0.08	0.58	861	1	0.04	18	350	10	82	0.08	67	56
548	1.0	2.34	25	90	1.04	13	29	73	3.46	40	0.10	0.65	516	5	0.06	17	490	6	32	0.14	96	62
549	1.0	2.94	30	80	1.46	16	33	937	3.46	60	0.17	0.73	501	3	0.14	18	690	6	42	0.13	93	206
550	1.0	2.51	30	120	0.59	17	28	65	3.12	30	0.20	0.84	399	10	0.05	21	470	6	32	0.12	80	70
552	1.0	2.94	70	120	0.96	30	31	82	4.45	40	0.20	0.88	757	18	0.04	40	600	14	40	0.19	114	106
553	1.0	1.83	20	190	0.93	11	28	30	3.17	190	0.13	0.61	411	1	0.04	16	720	8	38	0.15	88	58
555	1.0	2.60	5	80	1.56	13	19	26	3.21	40	0.04	0.92	727	1	0.03	12	380	4	59	0.20	96	48
556	1.0	2.31	20	90	1.21	14	24	49	3.55	100	0.06	0.87	605	1	0.07	18	540	6	45	0.14	68	64
557	1.0	1.91	25	140	1.10	15	21	42	3.84	970	0.08	0.77	638	1	0.05	23	460	8	47	0.07	73	74
559	1.0	2.55	5	150	1.01	16	35	42	3.81	60	0.12	0.82	645	1	0.03	32	370	10	64	0.08	60	76
560	1.0	3.21	10	110	1.79	16	32	38	4.06	50	0.09	1.05	673	1	0.06	20	410	8	90	0.18	109	68
562	1.0	2.49	20	50	0.90	24	62	44	6.61	50	0.05	1.07	971	1	0.02	48	560	12	35	0.06	80	84
563	1.0	1.61	40	80	0.68	11	12	39	2.89	50	0.12	0.51	510	1	0.06	7	560	42	37	0.11	61	88
564	1.0	1.99	75	110	0.51	31	28	41	4.49	50	0.07	0.53	823	1	0.02	22	390	30	27	0.10	129	152
568	1.0	2.92	30	110	1.27	23	104	71	3.92	1300	0.08	1.43	702	1	0.03	58	480	8	71	0.12	100	84
569	1.0	2.36	20	110	1.09	15	28	41	3.70	1200	0.10	0.81	573	1	0.05	22	400	10	78	0.14	95	72
570	1.0	2.83	20	230	1.05	17	34	45	4.09	850	0.19	0.88	679	1	0.04	35	460	8	78	0.08	87	86
572	1.0	1.85	45	140	0.84	16	30	41	4.34	900	0.11	0.81	648	1	0.04	23	630	2	61	0.10	105	98
573	1.0	2.61	15	160	1.26	17	32	44	4.22	360	0.14	1.00	678	1	0.05	34	550	8	74	0.11	95	78
574	1.0	2.93	5	170	2.29	15	20	48	4.11	70	0.13	0.84	723	1	0.08	11	1010	8	216	0.35	150	82
575	1.0	1.84	5	110	1.23	10	39	31	3.15	90	0.09	0.63	491	1	0.06	17	690	2	129	0.25	112	58
577	1.0	2.34	10	130	1.72	15	34	48	4.51	100	0.09	0.89	664	1	0.06	19	870	10	217	0.34	170	88
578	1.0	2.85	15	110	1.77	14	25	40	3.24	490	0.13	1.02	537	1	0.06	17	750	4	215	0.23	100	68
587	1.0	2.08	5	150	1.13	14	27	74	2.75	20	0.33	1.05	445	1	0.08	16	620	6	97	0.20	72	58
588	1.0	1.05	5	50	0.66	6	6	32	1.30	20	0.10	0.44	328	1	0.04	3	320	4	31	0.08	27	34
589	38.0	2.98	15	170	1.33	17	26	76	3.25	20	0.33	0.92	412	1	0.24	13	510	10	98	0.16	94	102
590	1.0	2.61	5	130	0.36	11	28	133	4.34	30	0.23	0.81	273	7	0.07	11	590	6	58	0.09	94	42
607	7.0	2.81	5	150	0.63	10	39	78	4.42	30	0.26	1.05	333	1	0.14	16	730	10	84	0.13	98	48
609	1.0	2.48	5	90	1.31	13	37	32	3.78	10	0.09	0.89	843	1	0.06	23	540	24	77	0.17	82	80
610	1.0	3.56	5	50	2.39	16	13	41	5.13	50	0.08	1.13	969	1	0.09	8	720	8	119	0.26	119	70
612	1.0	2.46	5	150	0.84	12	29	29	3.26	80	0.07	0.65	723	1	0.02	19	420	2	48	0.10	72	76
613	6.0	1.94	5	140	1.21	11	25	19	3.28	50	0.05	0.63	519	1	0.04	17	250	4	60	0.16	94	44
614	1.0	2.69	5	100	1.72	14	21	24	3.38	60	0.04	0.80	1030	1	0.05	13	440	6	79	0.24	103	46
615	4.0	3.06	75	70	0.95	20	45	52	5.02	50	0.05	1.32	913	1	0.04	26	610	10	44	0.16	104	74
616	1.0	2.59	25	70	1.10	18	46	52	4.04	40	0.04	1.02	729	1	0.04	27	480	10	35	0.14	74	74
617	6.0	2.60	85	70	1.08	14	48	63	3.42	60	0.04	0.91	615	7	0.02	21	500	6	37	0.11	92	70
618	1.0	2.40	45	90	1.18	12	29	35	3.19	50	0.04	0.83	885	1	0.02	14	620	6	55	0.11	80	70
619	2.0	3.81	5	170	1.23	22	32	100	4.24	60	0.13	1.65	846	2	0.02	20	520	22	62	0.14	92	134
620	1.0	2.26	5	50	0.98	16	11	144	3.40	40	0.08	1.27	615	1	0.03	6	580	4	29	0.14	73	58
622	2.0	1.82	5	60	0.43	12	31	32	3.58	30	0.03	0.63	601	1	0.02	26	410	10	17	0.09	39	66
623	20.0	1.95	25	60	1.15	11	21	60	2.93	20	0.05	0.67	483	1	0.08	13	520	10	29	0.09	49	52
624	1.0	1.75	5	40	0.47	13	29	44	3.62	20	0.04	0.60	569	1	0.01	22	400	8	14	0.13	36	70
625	5.0	1.79	5	60	0.35	13	36	32	3.55	20	0.03	0.62	573	1	0.02	34	390	10	16	0.07	36	72
626	1.0	3.37	5	150	1.92	16	40	43	4.28	30	0.10	1.18	679	1	0.05	22	540	12	108	0.23	107	66
627	2.0	2.31	50	130	0.71	15	29	40	4.01	40	0.10	0.65	748	1	0.03	22	390	14	37	0.12	49	88
628	1.0	0.92	5	60	0.45	8	16	24	2.64	20	0.16	0.34	181	1	0.06	8	430	6	25	0.07	58	26
629	1.0	1.07	5	70	0.59	6	19	22	2.05	20	0.14	0.42	232	1	0.05	7	690	10	31	0.09	58	32

TABLE A-2
STREAM SEDIMENT DATA FROM VOLCANIC AND SEDIMENTARY LITHOLOGIES — *Continued*

Sample No.	Au ppb	Al %	As ppm	Ba ppm	Ca %	Co ppm	Cr ppm	Cu ppm	Fe %	Hg ppb	K %	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sr ppm	Ti %	V ppm	Zn ppm
630	1.0	1.01	5	60	0.58	6	20	21	2.07	40	0.11	0.37	215	1	0.05	8	570	6	27	0.08	57	28
632	1.0	1.38	5	80	0.75	8	32	30	2.70	30	0.17	0.46	239	1	0.09	8	680	6	43	0.11	85	32
633	1.0	1.23	5	60	0.77	9	26	26	3.14	50	0.11	0.45	313	1	0.05	8	610	4	33	0.11	83	36
634	1.0	0.61	5	60	0.48	4	16	18	2.03	20	0.15	0.28	179	1	0.02	4	900	4	20	0.07	55	24
637	1.0	1.19	5	50	0.44	9	31	29	3.43	30	0.08	0.42	294	4	0.03	10	680	6	18	0.08	78	34
638	1.0	2.80	5	140	0.56	15	26	46	3.36	30	0.23	0.93	529	1	0.06	16	710	2	41	0.16	80	60
639	1.0	1.96	5	100	0.53	13	31	44	3.39	30	0.21	0.77	372	1	0.08	13	520	6	32	0.11	8	48
643	1.0	2.08	5	90	0.59	13	27	44	2.97	30	0.15	0.77	368	3	0.09	14	520	8	38	0.12	74	48
644	13.0	1.95	5	140	0.79	12	22	34	3.03	30	0.20	0.69	420	1	0.10	11	650	2	69	0.14	71	44
645	1.0	2.18	5	140	0.96	15	23	47	3.23	50	0.24	0.81	448	1	0.14	12	710	6	76	0.15	81	52
646	1.0	2.23	5	60	1.34	13	104	53	5.95	20	0.09	0.48	254	1	0.24	17	600	8	83	0.10	188	30
647	1.0	1.99	5	50	1.16	12	75	45	5.28	10	0.09	0.46	233	1	0.20	14	560	6	70	0.09	166	28
648	3.0	1.79	5	50	0.62	11	25	46	3.10	20	0.04	0.45	335	1	0.07	18	580	10	36	0.05	58	60
649	3.0	3.20	95	100	1.81	20	9	58	4.58	100	0.07	1.07	826	1	0.02	12	800	8	73	0.04	71	80
650	2.0	2.24	5	150	0.63	17	26	40	3.75	50	0.12	0.63	591	1	0.02	34	280	16	34	0.06	44	76
652	1.0	3.42	5	130	1.56	17	24	47	4.53	50	0.09	0.96	814	1	0.04	14	670	6	81	0.27	93	72
653	1.0	2.23	10	180	0.46	18	30	42	3.76	140	0.13	0.60	666	1	0.02	38	270	14	27	0.02	41	84
654	1.0	2.21	5	180	0.45	17	34	36	3.66	710	0.13	0.69	697	1	0.01	40	370	10	39	0.02	39	82
655	2.0	2.64	10	180	0.55	18	29	48	4.48	80	0.13	0.83	742	1	0.02	29	470	14	47	0.02	50	94
656	2.0	2.61	30	140	0.56	18	22	51	4.50	90	0.09	1.08	802	1	0.02	21	520	14	32	0.04	66	84
657	1.0	4.41	5	50	3.26	18	11	55	4.10	90	0.08	1.33	747	1	0.04	5	520	1	148	0.26	109	62
658	3.0	2.96	5	90	1.41	16	16	47	4.40	60	0.06	1.08	761	1	0.03	12	620	8	55	0.24	78	70
659	4.0	3.03	5	130	1.57	16	23	43	4.41	100	0.08	1.01	720	1	0.04	14	550	12	64	0.22	87	72
660	2.0	2.83	5	90	1.39	23	42	63	4.78	230	0.07	1.33	838	1	0.05	24	420	10	58	0.22	116	68
662	1.0	3.69	5	30	3.31	19	43	56	5.13	50	0.03	1.39	698	1	0.08	12	500	6	78	0.42	218	58
663	1.0	3.32	5	20	3.18	19	58	56	5.15	40	0.03	1.39	631	1	0.07	13	480	6	53	0.39	220	54
664	1.0	3.19	5	20	2.90	18	31	49	4.11	50	0.03	1.30	601	1	0.07	13	470	4	51	0.33	161	50
665	8.0	1.45	5	130	0.54	11	16	30	2.82	80	0.10	0.49	812	1	0.02	18	380	14	32	0.05	40	84
666	1.0	4.84	5	60	4.11	20	10	65	4.38	40	0.08	1.49	776	1	0.04	7	640	2	149	0.25	118	70
667	13.0	3.11	5	190	1.97	15	28	37	5.15	160	0.12	0.80	784	1	0.08	11	460	10	123	0.29	137	100
668	1.0	3.18	5	90	1.79	17	14	51	4.49	50	0.08	1.10	807	1	0.06	7	530	4	101	0.19	112	70
670	1.0	2.83	5	130	1.58	15	16	37	3.39	30	0.12	1.03	686	1	0.03	14	460	1	70	0.19	69	60
672	1.0	3.23	5	120	1.77	18	20	53	4.23	40	0.10	1.12	721	1	0.05	19	1630	4	131	0.20	81	72
673	1.0	3.23	5	140	1.68	17	26	45	4.89	1700	0.08	1.09	796	1	0.05	14	590	10	75	0.28	108	80
674	36.0	2.07	20	80	0.82	12	21	40	3.24	60	0.05	0.74	633	1	0.05	17	480	12	31	0.10	52	62
675	4.0	2.56	5	240	0.77	17	24	50	4.29	600	0.12	0.75	751	1	0.02	24	340	14	48	0.06	48	88
676	1.0	3.53	5	170	1.54	16	25	45	4.15	100	0.12	0.99	788	1	0.03	17	470	8	73	0.19	87	70
677	25.0	2.10	20	60	0.89	11	23	41	3.27	50	0.04	0.75	525	1	0.06	16	560	6	31	0.11	54	58
678	1.0	4.96	5	90	2.39	20	12	66	4.04	50	0.12	1.40	867	1	0.07	9	750	8	122	0.19	104	76
679	2.0	2.02	10	170	1.09	16	23	49	4.17	840	0.10	0.76	677	1	0.03	27	450	10	48	0.07	76	80
680	1.0	3.16	25	90	1.76	23	17	79	5.49	240	0.09	1.30	1012	1	0.04	11	660	12	80	0.15	130	76
682	1.0	3.22	5	90	2.11	19	25	52	5.05	80	0.07	1.18	887	1	0.05	13	500	12	82	0.23	153	82
683	1.0	4.21	5	80	1.49	20	19	54	5.10	40	0.07	1.40	752	1	0.05	13	570	8	68	0.24	142	74
684	2.0	2.87	5	60	2.26	16	33	45	3.61	40	0.09	1.33	540	1	0.12	22	500	2	79	0.25	113	52
685	7.0	3.29	35	110	0.92	14	25	45	3.58	50	0.08	0.94	637	1	0.02	19	680	6	52	0.12	93	60
687	1.0	4.08	5	70	2.09	20	17	68	4.60	40	0.08	1.34	770	1	0.04	13	600	4	78	0.30	127	74
688	3.0	4.26	10	60	2.56	20	14	70	4.23	30	0.11	1.50	816	1	0.09	11	770	2	107	0.27	114	74
689	8.0	2.33	10	120	1.33	16	24	47	4.29	90	0.08	0.94	627	1	0.03	21	520	8	57	0.05	57	82
690	1.0	2.71	20	110	0.78	19	40	62	5.07	50	0.06	0.95	637	1	0.01	49	460	12	39	0.10	51	102
692	1.0	1.85	5	90	0.91	11	17	20	3.14	50	0.09	0.67	464	1	0.04	16	370	10	39	0.18	55	50
693	1.0	2.44	15	130	0.57	18	31	42	4.63	100	0.10	0.88	697	1	0.02	36	410	8	42	0.05	59	96
694	1.0	2.12	30	110	0.49	15	24	32	3.83	100	0.13	1.03	600	1	0.02	29	590	8	47	0.05	59	68
695	1.0	3.01	15	150	1.31	16	21	34	3.93	40	0.11	1.17	663	1	0.04	19	470	4	70	0.20	80	66
696	1.0	3.91	20	140	2.81	17	21	39	4.46	310	0.14	1.15	753	1	0.07	11	630	6	173	0.21	115	74
697	6.0	3.29	40	100	1.16	33	132	107	5.15	3300	0.07	1.69	968	1	0.02	81	400	4	41	0.10	131	72
698	1.0	2.20	15	130	0.97	16	30	38	3.96	300	0.09	0.77	639	1	0.04	25	380	2	68	0.12	100	66
699	1.0	2.89	5	220	0.68	16	32	37	4.05	100	0.12	0.79	791	1	0.02	26	450	1	52	0.07	88	72
700	2.0	3.34	30	190	0.78	19	20	56	4.42	70	0.12	0.86	1286	1	0.02	19	650	6	64	0.02	90	80
702	3.0	2.17	25	240	0.48	18	28	46	4.34	170	0.13	0.48	809	1	0.02	35	400	14	34	0.03	81	78
703	1.0	3.09	20	170	1.64	19	26	47	5.09	110	0.12	1.04	817	1	0.05	28	480	10	106	0.14	132	86
704	1.0	1.76	5	70	1.57	12	20	29	3.38	60	0.05	0.77	578	1	0.04	16	370	4	37	0.13	71	46
705	1.0	1.70	10	220	0.79	13	15	32	3.84	440	0.10	0.65	895	1	0.03	11	500	2	40	0.08	84	72
706	2.0	1.51	30	250	0.88	18	24	44	4.29	570	0.12	0.59	679	1	0.02	41	350	10	65	0.01	53	84
707	1.0	1.63	40	250	0.71	14	20	36	3.76	3300	0.11	0.52	709	1	0.02	25	490	8	44	0.02	58	80
708	4.0	2.38	20	260	0.90	14	42	39	3.38	2300	0.11	0.67	681	1	0.03	28	430	8	59	0.05	72	76
709	1.0	3.28	5	30	2.93	16	16	28	5.09	50	0.04	1.18	624	1	0.16	6	540	1	106	0.29	161	54
710	10.0	2.28	35	210	1.19	17	20	44	4.13	230	0.24	0.91	642	1	0.03	28	670	14	93	0.01	61	76
712	1.0	4.08	15	90	2.12	20	21	48	4.81	60	0.10	1.45	788	1	0.05	18	570	4	111	0.21	141	72
713	1.0	3.17	10	70	2.39	16	18	31	4.79	50	0.07	1.15	649	1	0.12	13	550	4	101	0.25	144	58
715	1.0	2.90	5	190	1.05	18	25	38	4.84	130	0.15	1.06	680	1	0.08	23	450	4	98	0.10	124	78
716	1.0	2.82	20	290	0.69	19	37	37	4.42	430	0.16	0.97	804	1	0.02	51	420	12	70	0.06	84	84
717	1.0	2.60	35	190	1.06	19	31	44	4.48	740	0.14	1.03	881	1	0.07	25	740	12	87	0.11	112	80
718	7.0	3.10	20	110	1.67	20	57	54	6.70	450	0.08	1.13	837	1	0.07	19	640	16	125	0.25	238	110
719	1.0	2.41	45	190	0.92	20	26	47	4.65	1700	0.11	0.97	1092	1	0.04	19	740	10	58	0.07	110	86
720	21.0	2.37	5	160	1.32	16	33	33	4.50	310	0.11	0.90	648	1	0.05	28	550	2	75	0.14	113	72
722	18.0	3.75	35	160	2.10	29	36	94	5.18	400	0.12	1.30	1004	1	0.05	16	960	12	179	0.20	142	104
723	1.0	2.27	25	330	0.57	17	30	45	3.84	180	0.20	0.57	576	1	0.02	38	380	14	62	0.01	62	98
724	1.0	2.02	25	510	0.60	18	41	47	4.34	230	0.23	0.63	571	1	0.02	55	320	12	52	0.01	75	82
725	1.0	1.74	30	390	0.37	17	35	49	4.32	3000	0.20	0.48	594	1	0.01	52	250	12	37	0.01	66	92
726	2.0	3.33	15	280	0.84	18	34	37	4.27	100	0.17	0.91	823	1	0.02	37	430	6	61	0.06	90	78
727	1.0	1.96	35	180	0.69	17	29	38	4.28	450	0.13	0.75	731	1	0.03	30	570	8	77	0.03	86	80
728	1.0	2.04	45	160	0.80	19	30	43	4.66	1300	0.12	0.81	833	1	0.03	25	610	12	77	0.05	108	82
729	1.0	2.12	40	180	0.80	19	46	54	4.96	36000	0.12	0.87	873	1	0.04	26	860	10	61	0.07	121	92
730	1.0	2.61	20	210	1.01	17	33	42	4.21	550	0.15	0.86	651	1	0.03	37	450	10	75	0.08	92	76
732	1.0	1.82	10	360	0.55	17	38	44	4.14	2500	0.19	0.60	568	1	0.01	49	330	8	47	0.01	67	82
733	4.0	2.95	25	220	1.15	18	34	39	4.26	420	0.17	0.98	683	0	0.04	35	450	8	87	0.09	97	78
734	2.0	1.83	10	150	0.72	15	26	31	3.97	950	0.13	0.72	650	0	0.03	23	560	4	62	0.06	86	72

Notes: All Ag results are less than 0.8 ppm except for No. 506: = 2.0 ppm.
All Be, Bi, Cd results are less than or equal to 4 ppm.
All Sb results are less than or equal to 20 ppm except for the following: Nos. 428, 432, 433, 438, 439, 440, 442, 443 and 468 all equal 30 ppm.
All Ga, La results are less than or equal to 30 ppm.
All Tl, U, W results are less than or equal to 15 ppm.
All Au values of 0.5 ppb represent analyses below the detection limit.
All Ni, Mo, Pb values of 0 represent analyses below the detection limit.
All As values of 5 represent analyses below the detection limit.

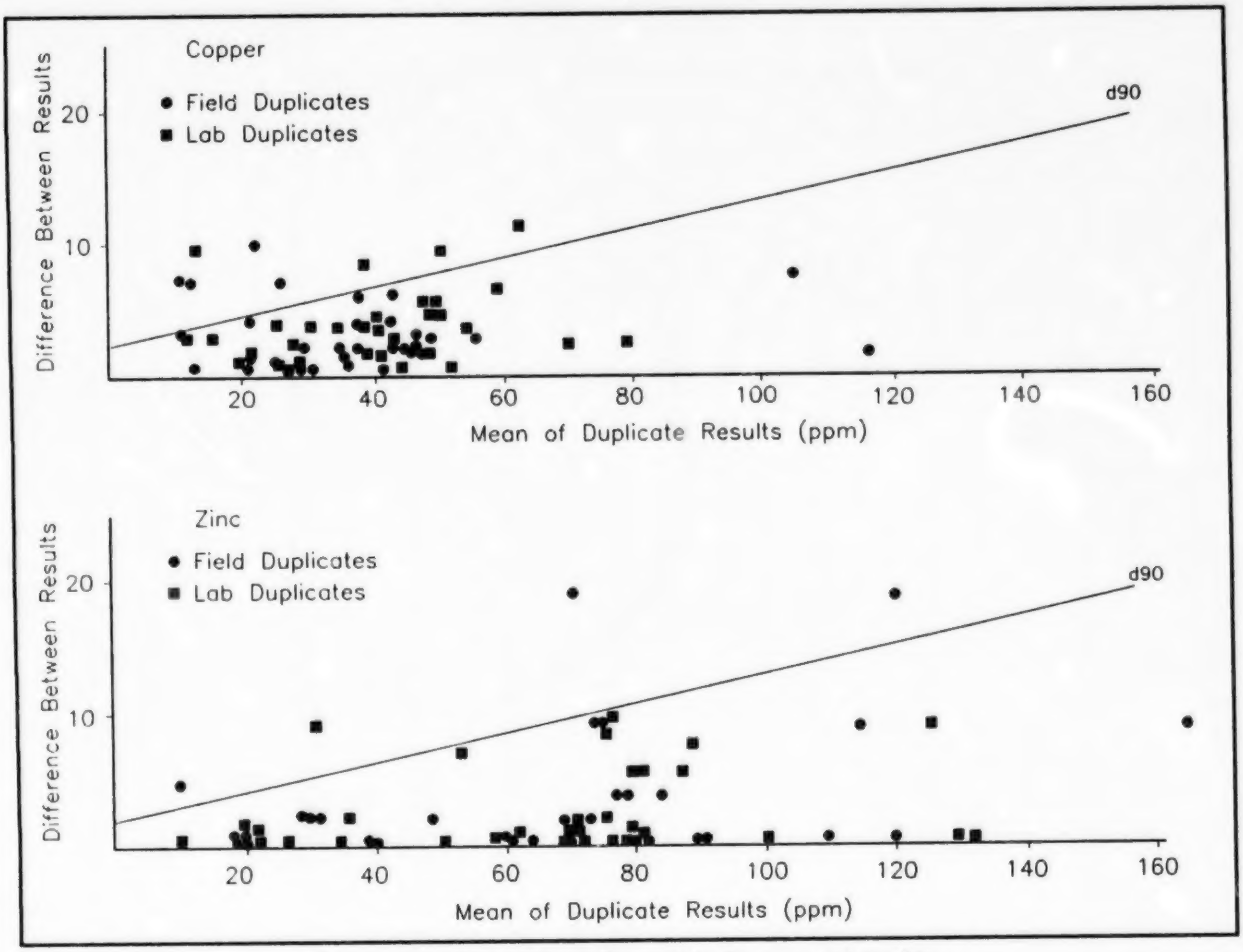

Figure A-1. Analytical and sampling precision for copper and zinc data.

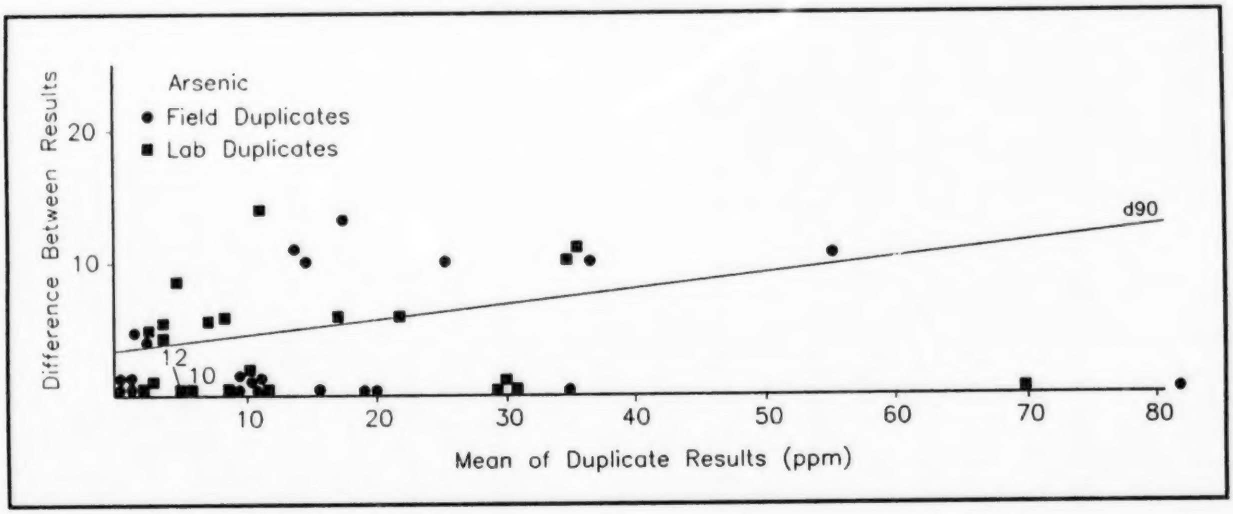

Figure A-2. Analytical and sampling precision for arsenic data.

TABLE A-3
COMPARISON OF ICP ANALYTICAL DATA WITH STANDARD REFERENCE MATERIALS

Element	Reference Material	Accepted Atomic Absorption Values		This Project ICP Analysis		Number of Replicates
		Mean	Std. Dev.	Mean	Std. Dev.	
Arsenic	T	4.6 ppm	1.0 ppm	5.5 ppm	1.6 ppm	10
	V	18.0	1.9	20.5	5.0	9
	N	3.1	1.0	5.8	2.0	6
	Y	12.2	2.3	9.1	6.7	7
Barium	T	1448 ppm	94 ppm	192 ppm	10 ppm	10
	V	1078	78	249	9	9
	N	1090	96	127	5	6
	Y	—	—	300	19	7
Cobalt	T	9.8 ppm	1.1 ppm	9.8 ppm	0.4 ppm	10
	V	31.8	3.3	36.4	1.9	9
		5.6	1.0	6.2	0.8	6
	Y	25.1	0.8	28.7	1.6	7
Copper	T	27.9 ppm	1.2 ppm	23.2 ppm	3.7 ppm	10
	V	83.8	2.5	81.2	6.6	9
	N	14.8	1.2	4.1	6.5	6
	Y	80.2	4.9	85.3	4.2	7
Iron	T	1.76%	0.08%	1.85%	0.10%	10
	V	3.63	0.16	4.03	0.17	9
	N	2.00	0.12	2.37	0.13	6
	Y	3.45	0.12	3.34	0.19	7
Manganese	T	484 ppm	24 ppm	487 ppm	21 ppm	10
	V	1011	28	1098	44	9
	N	573	32	589	33	6
	Y	1133	58	1089	53	7
Nickel	T	39 ppm	1.3 ppm	38 ppm	1.5 ppm	10
	V	335	13.3	340	11	9
	N	13	0.9	13	0.4	6
	Y	191	7.9	217	12	7
Lead	T	2.0 ppm	0.8 ppm	2.2 ppm	1.8 ppm	10
	V	18.4	0.9	19.3	2.4	9
	N	3.8	0.9	3.2	1.8	6
	Y	13.9	1.4	17.7	2.9	7
Zinc	T	43 ppm	4 ppm	41 ppm	2 ppm	10
	V	126	8	136	5	9
	N	44	4	45	6	6
	Y	112	4	107	6	7

population using a computer program developed by Stanley (1987).

Data were separated into one, two or three subpopulations based on their distribution characteristics; threshold values for anomalous and possibly anomalous populations were then determined. Figure 17 (a to o; Chapter 3) illustrates probability graphs and Table 4 (Chapter 3) provides a summary of population parameters and threshold levels for anomalous values. Table A-4 illustrates a correlation matrix for selected elements determined in the 462 samples taken in the volcanic and sedimentary lithology.

TABLE A-4
CORRELATION MATRIX FOR SELECTED ELEMENTS IN STREAM SEDIMENTS COLLECTED FROM VOLCANIC AND SEDIMENTARY LITHOLOGIES

	Au	As	Ba	Co	Cr	Cu	Fe	Hg
Au	1.0000							
As	.1914	1.0000						
Ba	−.0030	.2518	1.0000					
Co	.0110	.2546	.1076	1.0000				
Cr	−.0730	.0461	.1864	.2843	1.0000			
Cu	.1040	.0893	−.0326	.5810	.0688	1.0000		
Fe	−.0823	.0062	−.0460	.6613	.3879	.3438	1.0000	
Hg	.0750	.3512	.3925	.2585	−.0609	.1340	.0562	1.0000
Mn	−.0375	.1873	.1935	.6343	.1365	.2148	.7188	.2227
Mo	.1208	.2258	.1536	−.1000	−.0882	.3048	−.2283	.0298
Ni	−.0441	.2258	.3797	.5983	.7092	.1621	.3151	.1903
Pb	.2005	.2224	.3848	−.0575	−.0995	.0830	−.3010	.1566
Sr	−.2423	−.2092	.1359	.2519	.3628	.0778	.4498	−.0722
Ti	−.1928	−.3514	−.3061	−.0742	.2065	−.0159	.2099	−.3209
V	−.1828	−.2493	−.2056	.2296	.3933	.1837	.6974	−.1302
Zn	−.0548	.0916	.3456	.5193	.4187	.2260	.6730	.1040

	Mn	Mo	Ni	Pb	Sr	Tl	V	Zn
Mn	1.0000							
Mo	−.2341	1.0000						
Ni	.2938	−.1366	1.0000					
Pb	−.1579	.4547	.0621	1.0000				
Sr	.4228	−.2657	.1815	−.3304	1.0000			
Ti	.1102	−.1123	−.1809	−.3547	.5424	1.0000		
V	.4003	−.1681	−.0201	−.4488	.6511	.6498	1.0000	
Zn	.7256	−.1200	.4723	.3140	.4640	.1311	.4160	1.0000

Critical Value (2-tail, .05) = ± .0913
N = 462

APPENDIX B

LITHOGEOCHEMICAL SURVEY

ANALYTICAL PROCEDURES

The 368 rock-chip samples collected were analyzed by the British Columbia Geological Survey Branch analytical laboratory in Victoria. A total of 15 elements were determined on all samples. The analytical methods used were:

(1) a total acid digestion with atomic absorption analysis for Cu, Pb, Zn, Co, Ni, Mo, Mn, Cd, Fe, Bi, As and Sb. Lower values in arsenic and antimony were determined by hydride-generation atomic absorption analysis;

(2) fire assay with atomic absorption finish for gold; and

(3) cold vapour atomic absorption analysis for mercury.

In addition, tungsten was determined on the four samples from the Daisie skarn mineralization using an X-ray fluorescence technique.

Table B-1 lists the analytical results grouped according to mode of occurrence.

TABLE B-1
LITHOGEOCHEMICAL ANALYTICAL DATA — STRUCTURAL CONTROL OVER MODE OF OCCURRENCE

Veins

Sample No.	Au ppb	Ag ppm	Hg ppb	As ppm	Sb ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Fe %	Mo ppm	Mn ppm	Mode	Host
RB015	154	138.0	10000	<10	256	355	40600	10100	33	<10	1.8	38	690	1	6
RB030	43	<0.3	490	<10	<20	145	<10	14	34	<10	1.4	<10	80	1	6
RB031	70000	180.0	1800	<10	<20	850	<10	5	71	<10	5.0	17	24	1	6
RC011	21	3.4	665	121	<20	5383	<10	11	17	<10	2.1	<10	436	1	4
RC012	<20	7.5	2122	67	<20	14900	10	19	22	<10	5.3	<10	1094	1	4
RC013	<20	<0.3	37	<40	<20	35	<10	140	29	15	4.7	<10	1791	1	4
RC014	67	<0.3	<20	<40	<20	19	<10	97	22	13	3.7	<10	1189	1	4
RC015	<20	<0.3	<20	<40	<20	114	<10	<5	27	<10	2.5	<10	361	1	4
RC016	<20	<0.3	32	<40	<20	245	<10	81	24	<10	4.8	<10	953	1	4
RC019	<20	0.7	146000	50	202	585	11	54	10	34	4.4	<10	700	1	3
RC020	<20	0.4	84000	50	203	500	<10	49	5	26	2.9	<10	400	1	3
RC021	<20	0.4	42000	66	188	360	12	53	5	29	3.5	<10	700	1	3
RC023	<20	<0.3	1400	300	<20	69	13	70	12	42	6.1	<10	1500	1	9
RC024	<20	<0.3	1044	<40	<20	54	<10	76	19	<10	4.8	<10	1216	1	3
RC025	<20	3.4	1044000	97	308	1200	11	112	16	26	6.2	<10	1300	1	3
RC027	445	<0.3	10000	66	90	135	11	87	20	58	6.8	<10	1400	1	3
RC028	<20	0.8	328	24	<20	2200	<10	49	41	<10	1.5	<10	266	1	2
RC029	499	99.0	1200	260	<20	45000	26	1640	114	13	13.7	126	861	1	2
RC034	34	3.6	469	90	<20	900	40	80	38	<10	1.6	<10	395	1	12
RC035	86	54.0	8800	2700	440	16800	460	937	78	<10	4.8	17	1060	1	12
RC036	266	37.0	7800	1800	<20	14800	56	860	49	<10	5.4	18	723	1	12
RD011	<20	4.3	999	<40	<20	7698	<10	32	22	<10	5.4	<10	1123	1	4
RD012	<20	<0.3	32	<40	<20	548	<10	52	24	<10	4.3	<10	850	1	4
RD013	<20	<0.3	27	<40	<20	35	<10	103	21	17	4.4	<10	1048	1	4
RD014	<20	0.4	24	<40	<20	76	13	38	22	<10	3.7	<10	766	1	4
RD015	<20	0.5	87	<40	<20	1170	<10	63	21	<10	4.6	<10	982	1	4
RD023	<20	<0.3	24	<40	<20	19	10	59	5	<10	1.2	<10	408	1	9
RM003	<20	28.0	11000	488	127	17700	140	4800	37	15	3.8	<10	2600	1	4
RM018	<20	0.3	380	39	<20	54	<10	74	36	18	6.5	<10	867	1	6
RM044	<20	<0.3	<25	42	<20	14	<10	16	6	11	.9	<10	629	1	2
RM073	<20	<0.3	6100	<10	<20	35	<10	80	21	16	3.3	<10	1200	1	9
RM074	<20	<0.3	1000	<10	<20	33	<10	79	20	33	3.7	<10	1400	1	9
RM089	2400	5.0	295	<10	32	86	<10	9	63	<10	1.0	<10	36	1	12
RM090	7200	55.0	430	<10	26	800	42	114	82	<10	5.1	79	27	1	12
RM091	251	2.0	55	<10	32	16	<10	5	144	<10	0.6	<10	22	1	12
RM123	<20	<0.3	80	<40	<20	18	13	50	10	60	2.2	<10	5300	1	3
RM124	<20	<0.3	21	<40	<20	19	32	59	5	<10	6.4	<10	1800	1	3
RM128	<20	<0.3	140	<40	<20	65	<10	111	28	42	4.7	<10	725	1	1
RM129	<20	<0.3	392	94	<20	54	<10	96	26	60	4.0	<10	1100	1	1
RM130	<20	<0.3	640	142	<20	67	<10	77	18	44	4.0	<10	1300	1	1
RM131	<20	<0.3	615	137	58	63	<10	25	17	34	2.0	<10	145	1	1
RM143	<20	<0.3	113	<40	<20	7	<10	<5	95	<10	0.3	<10	60	1	2
RM155	<20	<0.3	29	<40	<20	188	<10	49	20	<10	0.6	<10	463	1	3
RM160	<20	<0.3	29	<40	<20	49	13	43	23	<10	3.1	<10	707	1	4
RM161	<20	0.7	195	86	<20	43	40	87	28	29	4.6	<10	1200	1	4
RM162	<20	<0.3	80	789	<20	25	20	70	18	26	4.0	<10	810	1	3
RM163	<20	0.6	727	<40	24	26	11	71	10	12	5.1	<10	1800	1	3
RM164	<20	<0.3	113	<40	<20	14	16	25	9	<10	1.3	<10	755	1	3
RM165	<20	<0.3	600	<40	<20	26	<10	55	31	12	1.7	<10	1300	1	3
RM166	<20	<0.3	1560	<40	<20	26	26	93	13	13	4.5	<10	1300	1	3

TABLE B-1
LITHOGEOCHEMICAL ANALYTICAL DATA — STRUCTURAL CONTROL OVER MODE OF OCCURRENCE — *Continued*

Veins

Sample No.	Au ppb	Ag ppm	Hg ppb	As ppm	Sb ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Fe %	Mo ppm	Mn ppm	Mode	Host
RM167	<20	0.9	57	<40	<20	2200	10	26	8	<10	1.5	<10	847	1	4
RM168	<20	2.0	560	<40	<20	6500	14	65	39	<10	5.0	<10	785	1	4
RM176	<20	<0.3	250	<40	<20	28	30	222	10	32	4.6	<10	1500	1	3
RM179	<20	<0.3	1350	<40	<20	18	18	160	24	17	5.2	<10	2200	1	9
RM184	<20	2.0	634000	34	60	300	35	179	24	31	6.1	<10	1300	1	9
RM185	<20	6.0	2240000	255	804	2800	13	184	23	29	6.7	<10	1700	1	9
RM186	<20	27.0	4500000	890	2600	8000	21	400	25	36	8.8	<10	2400	1	9
RM187	<20	<0.3	<20	<40	<20	11	21	156	25	23	1.0	<10	2300	1	9
RM190	<20	15.0	525000	40	95	160	12	124	19	62	5.5	<10	300	1	9
RM194	42	<0.3	<20	<10	<20	24	16	132	13	11	3.8	<10	2699	1	6
RM196	<20	<0.3	<20	<10	<20	88	12	14	20	27	2.0	<10	445	1	6
RM197	<20	<0.3	<20	<10	<20	24	<10	<5	10	19	2.9	<10	464	1	6
RM198	<20	<0.3	<20	<10	<20	106	<10	75	33	33	5.6	<10	1865	1	6
RM199	<20	<0.3	8500	4200	110	83	<10	87	30	120	5.2	<10	700	1	6
RM200	<20	<0.3	12100	3600	94	99	17	48	30	78	6.3	<10	1100	1	6
RM201	<20	<0.3	17600	4000	84	79	12	56	25	85	6.3	<10	1000	1	6
RM202	<20	<0.3	6600	2400	69	58	12	79	27	90	5.8	<10	1200	1	6
RM203	<20	<0.3	8000	1600	81	73	11	99	28	98	5.7	<10	700	1	6
RM204	101	<0.3	1300	72	<20	43	11	63	12	40	6.4	<10	1300	1	6
RM205	<20	<0.3	2700	97	<20	46	<10	38	10	40	6.9	<10	1700	1	6
RM206	201	<0.3	3300	290	70	79	13	96	29	97	7.1	<10	1000	1	6
RM301	72000	86	7000	560	26	2000	37	229	207	<10	16.5	<10	4000	1	9
RM302	760	1.0	710	38	<20	161	10	60	113	11	4.9	<10	370	1	9
RM303	180	<0.3	134	<10	<20	5400	18	240	39	28	8.0	<10	1500	1	9
RM308	<20	<0.3	30	12	<20	28	20	34	71	13	1.5	<10	290	1	6
RM309	60	0.5	<20	124	<20	111	20	127	40	45	4.5	<10	940	1	6
RM310	3900	40	41	11	24	171	956	253	63	<10	2.2	73	190	1	6
RM311	1900	21	184	99	29	150	422	91	40	12	2.2	20	250	1	6
RM312	<20	<0.3	42	49	<20	31	20	95	23	<10	6.2	<10	2200	1	6
RM313	<20	<0.3	<20	106	<20	17	14	95	16	<10	5.3	32	1500	1	6
RM322	<20	<0.3	<20	<10	<12	15	30	22	3	<10	2.0	<10	7700	1	4
RV031	<20	<0.3	265	<40	<20	32	<10	117	31	16	4.9	<10	2121	1	9

Carbonate Alteration Zones

Sample No.	Au ppb	Ag ppm	Hg ppb	As ppm	Sb ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Fe %	Mo ppm	Mn ppm	Mode	Host
RB019	<20	3.0	300	<10	<20	16	12	89	17	43	3.3	<10	710	2	9
RB025	<20	<0.3	295	<10	<20	16	10	71	13	20	3.2	<10	622	2	6
RC002	<20	<0.3	2198	2010	<20	22	<10	45	19	30	4.9	<10	690	2	3
RD024	<20	<0.3	199	<40	<20	17	<10	108	22	<10	2.4	<10	1339	2	9
RM002	84	0.5	2100	695	<20	14	14	37	12	<10	1.2	<10	171	2	8
RM060	<20	<0.3	310	59	<20	22	18	92	18	37	4.1	<10	1200	2	2
RM061	<20	<0.3	155	17	<20	19	<10	47	22	48	4.3	<10	1900	2	2
RM107	<20	<0.3	45	<40	<20	7	30	265	17	<10	5.6	<10	1700	2	3
RM181	<20	<0.3	169	<40	<20	41	17	115	21	27	2.9	<10	620	2	9
RM182	<20	<0.3	41	<40	<20	11	21	156	25	23	5.0	<10	1700	2	9
RM183	<20	<0.3	64	<40	41	15	11	62	17	12	2.2	<10	1000	2	9
RM188	<20	<0.3	2400	<40	<20	14	23	139	20	<10	4.6	<10	2000	2	9
RM191	<20	<0.3	203	<40	20	10	<10	20	18	<10	0.6	<10	117	2	9
RM192	<20	<0.3	950	<40	47	9	10	32	22	10	1.7	<10	695	2	9
RM316	<20	<0.3	406	<40	<20	33	<10	72	19	<10	4.4	<10	1000	2	6
RM317	<20	<0.3	1700	254	<20	14	<10	38	7	<10	2.3	<10	780	2	6
RM318	<20	<0.3	666	<40	<20	8	12	142	17	<10	4.6	<10	2300	2	6
RV022	24	<0.3	3854	<40	<20	121	<10	68	15	10	18.6	<10	494	2	9
RV026	49	<0.3	512	150	<20	26	11	84	14	<10	2.5	<10	810	2	3
RV027	<20	<0.3	323	<40	<20	76	<10	90	16	<10	5.1	<10	1697	2	3
RV028	<20	<0.3	37	<40	<20	<5	<10	51	5	<10	1.1	<10	743	2	3

TABLE B-1
LITHOGEOCHEMICAL ANALYTICAL DATA — STRUCTURAL CONTROL OVER MODE OF OCCURRENCE — *Continued*

Silica Alteration Zones

Sample No.	Au ppb	Ag ppm	Hg ppb	As ppm	Sb ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Fe %	Mo ppm	Mn ppm	Mode	Host
RB005	<20	<0.3	1800	<10	<20	66	4	18	15	<10	10.2	<10	255	3	4
RB006	<20	<0.3	970	18	<20	119	<10	129	45	10	10.1	<10	111	3	4
RB007	<20	<0.3	610	24	<20	112	<10	22	24	10	6.7	<10	54	3	4
RB008	<20	<0.3	555	<10	<20	22	<10	30	27	<10	5.6	<10	610	3	4
RB009	<20	<0.3	2100	<10	<20	21	<10	7	56	<10	6.9	<10	18	3	4
RC022	<20	<0.3	6485	<40	<20	268	<10	122	45	77	8.2	<10	1532	3	3
RC026	<20	<0.3	4767	<40	<20	105	<10	84	39	61	7.5	<10	1091	3	3
RD022	<20	<0.3	95	<40	<20	11	10	37	12	<10	0.7	<10	248	3	9
RD025	29	<0.3	48	<40	<20	14	17	45	27	<10	0.8	<10	446	3	9
RM022	<20	<0.3	520	10	<20	80	<10	78	30	<10	5.3	<10	876	3	5
RM066	<20	<0.3	145	<10	<20	17	<10	24	21	<10	2.5	<10	138	3	9
RM067	<20	22.0	3600	<10	<20	22600	46	91	20	19	6.5	<10	800	3	9
RM068	<20	0.5	245	10	<20	58	<10	100	17	18	4.8	<10	1100	3	9
RM092	1430	1.0	550	<10	<20	13	24	58	41	<10	2.5	<10	294	3	12
RM144	<20	0.6	20	<40	<20	45	14	10	33	<10	3.0	<10	17	3	2
RM145	20	<0.3	35	<40	<20	31	<10	<5	68	<10	2.0	<10	17	3	2
RM146	<20	<0.3	35	<40	<20	15	<10	<5	49	<10	2.3	<10	13	3	2
RM177	<20	<0.3	300	<40	<20	11	<10	44	21	11	1.6	<10	260	3	3
RM178	<20	<0.3	2100	<40	<20	50	20	152	23	<10	5.3	<10	2300	3	9
RM180	138	<0.3	2080	393	38	11	<10	143	33	<10	8.1	<10	2200	3	9
RM189	<20	<0.3	859	<40	62	7	12	79	17	<10	2.2	<10	886	3	9

Fault Zones

Sample No.	Au ppb	Ag ppm	Hg ppb	As ppm	Sb ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Fe %	Mo ppm	Mn ppm	Mode	Host
RB003	<20	<0.3	200	<10	<20	90	<10	40	31	66	3.1	<10	723	4	4
RB004	<20	<0.3	1100	<10	<20	28	11	66	13	20	4.1	<10	668	4	4
RB013	<20	<0.3	175	15	<20	12	<10	33	27	<10	3.4	<10	20500	4	6
RB014	22	<0.3	270	<10	<20	20	12	87	32	12	5.2	<10	845	4	6
RB016	<20	10.0	900	<10	<20	98	33	170	20	12	2.8	<10	450	4	6
RC003	<20	<0.3	43	<40	<20	24	25	38	26	<10	3.0	<10	963	4	6
RC004	21	<0.3	27	<40	<20	35	14	70	50	13	3.2	<10	860	4	6
RC010	<20	<0.3	218	47	<20	47	<10	75	22	18	5.7	27	418	4	4
RC017	<20	<0.3	24	<40	<20	24	<10	123	27	11	4.5	<10	1537	4	4
RC018	<20	<0.3	320	44	<20	37	<10	48	18	<10	3.7	21	380	4	9
RD003	<20	<0.3	233	3750	<20	35	73	197	15	<10	1.4	<10	3803	4	3
RD004	<20	<0.3	74	<40	<20	52	<10	80	32	<10	2.2	<10	577	4	4
RD005	<20	<0.3	134	<40	<20	32	<10	44	25	<10	2.0	<10	549	4	4
RD006	<20	<0.3	37	<40	<20	42	<10	40	27	<10	2.0	<10	624	4	4
RD007	<20	<0.3	84	<40	<20	204	<10	74	19	<10	4.0	<10	596	4	4
RD008	<20	<0.3	21	<40	<20	63	<10	78	23	<10	1.9	<10	756	4	4
RD009	<20	<0.3	380	<40	51	45	<10	171	22	18	5.3	<10	1950	4	4
RD010	<20	<0.3	1318	<40	60	29	<10	421	27	<10	7.8	<10	4811	4	4
RD016	<20	0.4	390	<40	<20	65	<10	111	18	<10	6.0	10	662	4	4
RD017	<20	<0.3	56	<40	<20	40	<10	118	27	14	3.5	<10	1198	4	4
RD018	<20	<0.3	121	<40	<20	42	<10	48	16	12	5.3	<10	540	4	9
RD019	<20	<0.3	262	<40	<20	63	10	66	13	<10	4.7	<10	643	4	9
RD020	<20	<0.3	636	<40	<20	52	<10	97	17	<10	4.7	<10	719	4	9
RD021	138	<0.3	453	102	<20	35	<10	56	29	23	5.2	<10	427	4	3
RD029	<20	<0.3	727	85	<20	50	12	58	22	42	5.3	<10	1050	4	6
RD030	<20	<0.3	78	55	<20	27	<10	27	10	29	5.4	<10	1378	4	6
RF002	<20	<0.3	720	<10	<20	1100	<10	43	20	21	4.1	<10	1000	4	4
RM001	<20	0.4	575	<10	<20	62	<10	84	20	11	6.3	<10	585	4	4
RM004	<20	<0.3	1600	43	<20	122	<10	97	43	12	6.5	<10	519	4	4
RM009	<20	<0.3	1700	101	<20	57	<10	104	30	24	7.7	<10	1800	4	6
RM012	<20	<0.3	85	58	<20	7	<10	87	20	<10	2.8	<10	825	4	6
RM013	<20	<0.3	495	42	<20	30	<10	60	28	19	4.7	<10	531	4	6
RM020	<20	<0.3	150	90	<20	115	<10	86	22	<10	5.5	<10	1000	4	4
RM021	<20	<0.3	520	120	<20	25	<10	74	13	<10	5.7	<10	1200	4	4
RM025	<20	<0.3	125	<10	<20	41	<10	38	19	<10	4.4	<10	733	4	2
RM026	<20	<0.3	110	<10	<20	69	<10	54	28	12	6.1	<10	992	4	2
RM027	<20	<0.3	110	30	<20	56	10	69	25	<10	6.0	<10	1400	4	2
RM028	<20	<0.3	500	<10	<20	22	<10	48	11	<10	5.2	<10	390	4	2

TABLE B-1
LITHOGEOCHEMICAL ANALYTICAL DATA — STRUCTURAL CONTROL OVER MODE OF OCCURRENCE — *Continued*

Fault Zones

Sample No.	Au ppb	Ag ppm	Hg ppb	As ppm	Sb ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Fe %	Mo ppm	Mn ppm	Mode	Host
RM029	<20	<0.3	230	<10	<20	42	<10	46	15	<10	3.8	<10	981	4	2
RM030	<20	<0.3	385	30	<20	26	<10	84	15	<10	5.3	<10	1800	4	2
RM031	<20	<0.3	150	110	<20	62	20	127	25	18	5.7	<10	2100	4	2
RM032	<20	<0.3	85	46	<20	53	11	60	23	<10	4.7	<10	1600	4	2
RM033	<20	<0.3	90	<10	<20	51	29	59	23	17	4.3	<10	1000	4	2
RM034	<20	<0.3	400	<10	<20	126	19	127	37	77	7.3	<10	1400	4	6
RM041	<20	<0.3	260	<10	<20	69	<10	124	36	24	8.6	<10	1000	4	2
RM042	<20	<0.3	60	<10	<20	58	10	88	31	16	5.8	<10	1300	4	2
RM043	<20	<0.3	50	<10	<20	34	10	71	24	10	4.9	<10	772	4	2
RM047	<20	<0.3	270	36	<20	64	<10	99	19	11	5.5	<10	957	4	6
RM050	66	1.0	620	26	<20	63	37	64	24	<10	6.7	<10	734	4	2
RM064	<20	<0.3	2500	149	<20	45	15	39	8	<10	3.7	<10	73	4	8
RM103	90	<0.3	30	<40	<20	286	<10	52	37	14	5.6	<10	600	4	3
RM108	<20	<0.3	122	<40	<20	19	<10	53	14	<10	4.1	<10	890	4	6
RM120	<20	<0.3	230	<40	<20	29	12	67	19	<10	3.5	<10	620	4	9
RM121	<20	<0.3	75000	10300	109	93	18	124	16	46	4.1	<10	832	4	3
RM122	<20	<0.3	332	<40	<20	78	<10	72	10	42	4.3	<10	370	4	3
RM141	<20	<0.3	29	<40	<20	42	<10	25	5	<10	6.1	<10	113	4	2
RM142	<20	<0.3	<20	<40	<20	16	10	64	27	<10	3.9	<10	943	4	2
RM150	<20	<0.3	145	<40	<20	32	12	91	23	15	6.6	<10	555	4	3
RM151	<20	<0.3	506	<40	<20	33	109	126	15	19	3.6	<10	573	4	3
RM152	<20	<0.3	22	<40	<20	51	14	108	21	<10	4.3	<10	1200	4	3
RM153	<20	<0.3	41	<40	<20	61	12	62	20	12	4.2	<10	735	4	3
RM154	<20	<0.3	20	<40	<20	57	11	53	20	12	5.0	<10	1100	4	3
RM158	<20	<0.3	36	<40	<20	282	12	50	29	<10	6.9	<10	1000	4	3
RM175	<20	<0.3	640	<40	<20	64	<10	82	21	<10	5.2	<10	584	4	4
RM207	<20	<0.3	52	<10	<20	74	<10	73	39	99	6.0	<10	1140	4	6
RM208	<20	<0.3	24	<10	<20	45	<10	67	23	66	4.8	<10	743	4	6
RM314	<20	<0.3	180	222	<20	21	<10	76	26	<10	6.3	<10	1100	4	6
RM315	<20	<0.3	123	78	<20	33	19	71	23	10	5.4	<10	650	4	6
RM319	<20	<0.3	<20	<10	<20	125	10	85	29	16	6.0	<10	630	4	6
RM321	<20	<0.3	216	<10	<20	31	<10	58	17	21	2.9	<10	890	4	4
RV010	<20	9.6	54	<40	<20	12300	<10	99	34	11	7.4	<10	1434	4	4
RV012	<20	<0.3	<20	<40	<20	36	16	129	22	25	3.8	<10	601	4	6
RV013	<20	<0.3	39	<40	<20	88	<10	94	29	17	6.1	<10	1113	4	1
RV018	<20	<0.3	<20	<40	<20	58	<10	66	26	12	4.7	10	641	4	3
RV019	<20	<0.3	160	<40	<20	20	<10	50	10	13	3.4	<10	373	4	4
RV020	<20	7.5	157	<40	<20	11900	<10	70	27	10	4.3	<10	926	4	4
RV021	<20	<0.3	54	<40	<20	60	<10	114	25	12	5.1	<10	1140	4	4
RV023	<20	<0.3	323	<40	<20	12	<10	63	25	<10	4.5	<10	182	4	9
RV024	<20	<0.3	91	<40	<20	48	<10	41	26	<10	4.7	<10	177	4	9
RV025	<20	<0.3	671	<40	<20	98	<10	66	24	26	5.6	<10	1176	4	9
RV029	<20	<0.3	83	<40	<20	20	<10	59	14	10	3.6	<10	3020	4	9
RV030	<20	<0.3	257	<40	<20	22	<10	49	21	50	3.1	35	556	4	3
RV032	<20	<0.3	33	<40	<20	18	<10	172	30	18	5.2	<10	1617	4	9
RV033	<20	<0.3	160	<40	<20	<5	<10	34	17	<10	1.0	<10	485	4	4

TABLE B-1
LITHOGEOCHEMICAL ANALYTICAL DATA — INTRUSIVE CONTROL OVER MODE OF OCCURRENCE

Hornfels Zones

Sample No.	Au ppb	Ag ppm	Hg ppb	As ppm	Sb ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Fe %	Mo ppm	Mn ppm	Mode	Host
RB001	<20	<0.3	1300	<10	<20	13	13	174	14	10	1.9	<10	336	5	8
RB002	61	0.4	3000	410	315	415	<10	320	71	30	13.6	<10	1700	5	8
RB010	<20	<0.3	340	150	<20	80	32	172	39	67	6.0	<10	630	5	6
RB011	22	<0.3	675	<10	<20	7	15	39	28	<10	3.9	<10	413	5	6
RB018	<20	5.0	1700	<10	<20	60	<10	103	23	12	5.7	<10	822	5	8
RB024	<20	<0.3	1100	<10	<20	253	10	142	36	201	9.9	<10	1900	5	6
RB026	<20	<0.3	360	<10	<20	52	10	22	35	<10	1.8	<10	90	5	12
RB027	<20	<0.3	185	<10	<20	41	<10	52	38	12	2.3	<10	342	5	12
RB028	<20	<0.3	95	<10	<20	19	<10	54	40	<10	1.4	<10	307	5	12
RB029	22	<0.3	825	<10	<20	395	10	186	40	19	6.7	<10	1900	5	6
RB032	59	1.0	255	<10	<20	43	12	153	14	27	4.0	<10	790	5	11
RC030	<20	<0.3	22	26	<20	85	<10	109	27	33	4.8	<10	951	5	2
RC031	<20	<0.3	20	<10	<20	228	<10	113	41	15	10.4	<10	1994	5	2
RC032	<20	<0.3	<20	15	<20	263	<10	149	43	18	10.6	<10	2133	5	2
RC033	60	<0.3	<20	<10	<20	88	<10	40	22	<10	3.6	<10	484	5	2
RD026	<20	<0.3	20	<10	<20	48	<10	78	34	110	6.0	<10	1130	5	6
RD027	<20	<0.3	20	26	<20	<10	10	89	<5	<10	3.4	<10	1170	5	6
RD028	<20	<0.3	60	14	<20	<10	<10	76	<5	<10	3.5	<10	1120	5	6
RD035	<20	<0.3	50	17	<20	68	<10	30	13	25	5.3	<10	1338	5	6
RD036	<20	<0.3	28	11	<20	88	<10	49	40	<10	2.8	<10	445	5	6
RM036	26	<0.3	220	60	<20	80	16	87	25	18	5.1	<10	1500	5	6
RM048	<20	<0.3	135	10	<20	52	<10	115	25	42	5.3	<10	789	5	2
RM049	<20	<0.3	120	34	<20	49	12	104	22	37	5.2	<10	635	5	2
RM076	<20	<0.3	215	<10	<20	219	<10	92	21	47	3.8	<10	841	5	9
RM083	<20	<0.3	55	<10	<20	343	<10	18	330	11	6.6	14	1100	5	9
RM085	<20	0.3	25	<10	<20	313	<10	63	51	30	6.6	<10	978	5	9
RM086	<20	<0.3	82	<10	<20	210	<10	34	49	29	6.0	24	820	5	9
RM088	<20	1.5	1400	<10	35	362	<10	34	44	42	4.1	<10	33200	5	9
RM101	<20	<0.3	30	<40	<20	121	22	84	30	15	5.5	<10	850	5	2
RM102	<20	<0.3	<20	<40	<20	35	16	57	25	40	3.8	<10	520	5	2
RM109	<20	<0.3	20	<40	<20	50	30	132	24	<10	4.0	<10	900	5	2
RM110	37	<0.3	20	<40	<20	54	12	163	26	17	6.1	<10	1200	5	2
RM111	<20	<0.3	<20	<40	<20	40	13	86	32	<10	6.1	<10	1300	5	2
RM112	24	<0.3	<20	<40	<20	25	17	41	21	<10	0.2	<10	530	5	2
RM113	<20	<0.3	<20	<40	<20	45	<10	50	23	<10	3.6	<10	503	5	2
RM114	<20	<0.3	<20	<40	<20	125	15	60	44	<10	4.5	<10	600	5	2
RM132	<20	<0.3	41	<40	<20	77	60	109	35	44	6.2	<10	1600	5	1
RM133	<20	0.5	77	<40	<20	112	19	52	19	11	4.0	42	692	5	1
RM134	69	<0.3	179	<40	<20	291	39	470	30	47	7.7	43	900	5	1
RM135	<20	<0.3	25	<40	<20	91	12	133	27	21	5.6	<10	1000	5	1
RM136	<20	<0.3	<20	<40	<20	83	<10	99	25	<10	5.8	<10	1500	5	1
RM137	<20	<0.3	23	<40	<20	52	<10	74	23	<10	5.3	<10	1200	5	1
RM138	<20	<0.3	26	<40	<20	94	<10	78	20	19	7.9	12	840	5	1
RM139	<20	<0.3	20	<40	<20	80	<10	101	33	115	5.6	<10	1300	5	1
RM147	<20	<0.3	<20	<40	<20	48	10	53	23	11	4.3	<10	648	5	6
RM148	<20	<0.3	<20	<40	<20	43	15	179	28	94	4.6	<10	655	5	6
RM149	<20	<0.3	<20	<40	<20	58	11	134	18	49	7.6	<10	755	5	6
RM174	<20	<0.3	28	<40	<20	61	<10	57	43	<10	4.8	<10	268	5	2
RM195	84	<0.3	<20	<10	<20	53	<10	66	36	121	6.6	<10	723	5	6
RM320	<20	<0.3	<20	29	<20	55	10	74	26	<10	4.0	<10	800	5	6
RV001	69	<0.3	<20	<40	<20	92	<10	84	31	31	4.8	<10	1332	5	2
RV006	62	<0.3	22	<40	<20	10	<10	20	27	<10	3.1	<10	284	5	2
RV007	<20	<0.3	29	<40	<20	46	<10	74	32	34	4.5	<10	1024	5	2
RV008	<20	<0.3	24	<40	<20	42	10	123	36	27	5.6	<10	1532	5	2
RV009	24	<0.3	31	<40	<20	16	13	<5	16	<10	1.1	10	66	5	2
RV011	20	<0.3	<20	<40	<20	60	10	91	32	12	3.1	<10	1274	5	2
RV014	<20	<0.3	<20	<40	<20	42	<10	99	24	<10	6.2	<10	1764	5	2
RV015	<20	<0.3	29	<40	<20	80	<10	105	13	22	7.4	<10	596	5	2
RV016	<20	<0.3	<20	<40	<20	66	<10	70	32	<10	6.5	<10	1752	5	1
RV017	<20	<0.3	<20	<40	<20	42	<10	93	35	<10	6.4	<10	1416	5	1
RV034	68	0.6	69	326	<20	30	<10	260	<5	<10	2.5	<10	1030	5	2
RV035	29	<0.3	78	25	<20	36	<10	48	33	<10	5.3	<10	1180	5	6
RV036	<20	<0.3	113	24	<20	<10	<10	47	15	<10	0.5	<10	38	5	6

TABLE B-1
LITHOGEOCHEMICAL ANALYTICAL DATA — INTRUSIVE CONTROL OVER MODE OF OCCURRENCE — *Continued*

Skarns

Sample No.	Au ppb	Ag ppm	Hg ppb	As ppm	Sb ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Fe %	Mo ppm	Mn ppm	Mode	Host
RM075	<20	<0.3	440	<10	<20	152	<10	112	20	40	10.2	11	2500	6	9
RM100	162	80.0	257	71	<20	51000	<10	7600	240	212	36.6	22	900	6	1
RM104	67	33.0	129	<40	<20	20500	13	1900	50	39	11.4	460	500	6	1
RM105	63	60.0	188	<40	<20	40000	<10	2300	42	30	12.6	162	560	6	1
RM106	46	30.0	114	<40	<20	17300	<10	1400	40	42	11.4	<10	390	6	1

Porphry and Stockwork Zones

Sample No.	Au ppb	Ag ppm	Hg ppb	As ppm	Sb ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Fe %	Mo ppm	Mn ppm	Mode	Host
RB017	<20	7.0	3400	<10	<20	7	13	37	28	<10	2.8	<10	38	7	6
RB020	<20	2.0	650	<10	<20	16	12	154	18	43	4.0	<10	873	7	10
RB021	<20	<0.3	510	<10	<20	46	<10	50	18	27	3.4	<10	372	7	9
RB022	<20	<0.3	1700	<10	<20	91	11	86	51	29	14.1	12	950	7	9
RB023	<20	<0.3	720	<10	<20	32	10	113	25	<10	5.4	<10	950	7	12
RD002	<20	49.0	651	<40	<20	3717	1343	1135	40	<10	13.6	461	8265	7	12
RD031	94	2.3	66	64	<20	4500	<10	122	26	33	5.1	<10	782	7	12
RD032	2020	3.1	<20	107	<20	4700	28	138	33	11	3.1	32	544	7	12
RD033	315	0.6	20	55	<20	33400	34	404	45	<10	0.9	17	911	7	12
RD034	50	6.4	466	1200	32	21200	107	570	43	14	1.7	25	604	7	12
RF003	<20	<0.3	352	<10	<20	99	<10	83	34	11	5.0	<10	768	7	6
RF004	<20	3.0	523	15	180	13	<10	73	17	15	4.7	<10	1700	7	6
RF008	<20	<0.3	255	<10	<20	20	<10	93	21	43	4.0	<10	1300	7	9
RM035	<20	<0.3	810	54	<20	199	28	195	23	<10	4.9	<10	1900	7	6
RM037	<20	9.0	3700	<10	<20	17600	16	108	17	123	4.8	30	1400	7	10
RM038	<20	<0.3	150	62	<20	204	10	35	28	<10	3.5	<10	331	7	10
RM039	67	1.0	575	40	<20	4000	14	70	34	<10	5.3	<10	782	7	10
RM077	<20	0.4	130	<10	<20	255	<10	33	30	28	4.6	10	435	7	10
RM078	<20	0.3	402	<10	<20	300	<10	29	36	38	4.0	<10	355	7	10
RM079	<20	<0.3	138	<10	<20	420	<10	38	41	<10	8.1	<10	972	7	9
RM080	<20	1.0	138	<10	<20	1200	<10	39	66	16	7.8	<10	986	7	9
RM081	<20	0.4	152	<10	<20	940	<10	36	57	45	3.3	52	315	7	10
RM082	<20	0.4	215	<10	<20	1100	<10	39	61	16	5.5	<10	605	7	9
RM084	44	3.0	115	<10	20	4800	<10	57	56	45	4.4	<10	448	7	10
RM087	<20	0.3	55	<10	<20	207	<10	36	24	10	6.3	42	729	7	9
RM125	20	18.0	680	<40	<20	7500	1200	1300	20	<10	6.9	15	4200	7	12
RM173	298	14.0	135	<40	<20	18400	<10	404	104	<10	4.4	1700	141	7	2
RM304	<20	1.0	<20	<10	<20	3500	<10	11	97	<10	1.3	66	70	7	12
RM305	50	2.0	<20	<10	<20	5200	<10	19	75	<10	1.7	2300	80	7	12
RM306	<20	1.0	78	<10	<20	2400	47	72	49	13	5.1	187	430	7	12
RM307	40	1.0	<20	<10	<20	5800	12	43	49	16	5.2	1200	330	7	12

TABLE B-1
LITHOGEOCHEMICAL ANALYTICAL DATA — UNCERTAIN CONTROL OVER MODE OF OCCURRENCE

Gossans

Sample No.	Au ppb	Ag ppm	Hg ppb	As ppm	Sb ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Fe %	Mo ppm	Mn ppm	Mode	Host
RB012	<20	<0.3	225	<10	<20	22	10	95	22	66	3.9	<10	80000	8	6
RC001	<20	<0.3	22	51	<20	145	10	60	40	<10	6.0	<10	935	8	3
RC005	<20	<0.3	124	<40	<20	88	<10	60	37	14	6.3	<10	549	8	2
RC006	<20	<0.3	35	47	<20	78	<10	30	49	<10	4.2	14	521	8	3
RC007	<20	<0.3	48	47	<20	99	<10	85	34	10	5.8	34	1170	8	3
RC008	<20	<0.3	30	47	<20	81	<10	26	53	13	4.7	17	944	8	3
RC009	46	<0.3	24	47	<20	88	<10	70	43	17	5.7	21	1726	8	3
RD001	<20	0.6	48	<40	<20	99	24	110	51	43	13.2	18	1161	8	2
RF001	<20	<0.3	200	<10	<20	33	<10	115	18	<10	4.9	<10	1200	8	4
RF005	<20	1.0	410	310	<20	65	10	131	28	15	5.3	<10	1000	8	2
RF006	<20	<0.3	220	16	<20	71	<10	87	20	49	5.8	<10	1300	8	2
RF007	<20	9.0	220	<10	<20	12	10	55	25	<10	1.5	<10	442	8	2
RM005	<20	0.8	440	<10	<20	70	<10	76	38	85	6.8	<10	1300	8	6

TABLE B-1
LITHOGEOCHEMICAL ANALYTICAL DATA — UNCERTAIN CONTROL OVER MODE OF OCCURRENCE — *Continued*

Gossans

Sample No.	Au ppb	Ag ppm	Hg ppb	As ppm	Sb ppm	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Fe %	Mo ppm	Mn ppm	Mode	Host
RM006	<20	5.0	365	<10	<20	49	<10	81	25	79	5.9	<10	1100	8	6
RM007	<20	0.3	500	<10	<20	100	<10	61	38	127	6.8	<10	1400	8	6
RM008	<20	<0.3	270	<10	<20	45	<10	91	21	30	6.1	16	908	8	6
RM010	<20	0.4	770	145	<20	24	14	41	47	30	5.4	<10	2900	8	6
RM011	<20	<0.3	210	126	<20	5	16	95	22	<10	2.2	6	608	8	6
RM014	<20	23.0	205	18	<20	45	114	616	30	90	5.6	<10	1600	8	6
RM015	<20	<0.3	300	22	<20	150	12	60	30	43	4.5	<10	478	8	6
RM016	<20	0.3	510	50	<20	30	<10	59	30	33	5.2	<10	657	8	6
RM017	<20	<0.3	110	<10	<20	36	12	78	26	34	4.7	<10	585	8	6
RM019	<20	<0.3	125	<10	<20	45	12	83	25	24	4.0	<10	646	8	4
RM024	<20	<0.3	130	<10	<20	34	<10	30	24	<10	4.4	<10	842	8	6
RM040	<20	0.2	270	20	<20	860	79	200	16	53	2.3	<10	5400	8	6
RM045	<20	<0.3	635	49	<20	20	<10	95	25	<10	2.6	<10	160	8	6
RM046	<20	<0.3	3800	255	21	33	10	100	24	<10	6.7	<10	760	8	6
RM051	<20	<0.3	400	33	<20	100	<10	108	20	<10	7.8	<10	1000	8	2
RM052	112	<0.3	370	345	<20	99	24	118	25	<10	7.8	<10	1100	8	2
RM053	<320	<0.3	60	65	<20	9	10	54	28	<10	2.8	<10	489	8	2
RM054	53	<0.3	30	32	<20	7	<10	32	22	<10	1.8	<10	80	8	2
RM055	48	<0.3	80	46	<20	6	<10	32	24	<10	1.9	<10	80	8	2
RM056	55	<0.3	50	68	82	8	<10	37	26	<10	1.9	<10	72	8	2
RM057	26	<0.3	60	55	24	7	13	101	28	<10	1.9	<10	99	8	2
RM058	<20	<0.3	50	28	<20	7	11	26	26	<10	2.4	<10	65	8	2
RM059	<20	<0.3	40	106	<20	11	<10	30	21	<10	2.0	<10	67	8	2
RM062	<20	<0.3	105	14	<20	38	<10	74	33	14	4.4	<10	615	8	2
RM063	71	<0.3	140	10	<20	46	<10	87	27	18	5.3	<10	835	8	2
RM065	<20	<0.3	510	17	<20	50	<10	85	38	107	5.4	<10	1100	8	8
RM069	<20	<0.3	365	<10	<20	41	<10	85	22	17	5.6	<10	842	8	9
RM070	<20	<0.3	170	<10	<20	58	<10	69	24	28	5.7	<10	909	8	9
RM071	<20	<0.3	60	<10	<20	28	<10	84	21	20	4.6	<10	704	8	9
RM072	<20	<0.3	50	<10	<20	27	<10	78	17	23	4.0	<10	650	8	9
RM115	<20	<0.3	<20	<40	<20	35	11	89	25	<10	5.1	<10	1200	8	2
RM116	<20	<0.3	23	<40	<20	10	14	67	29	<10	1.9	<10	490	8	2
RM117	<20	<0.3	96	<40	<20	10	21	46	25	<10	1.9	<10	410	8	2
RM118	<20	<0.3	<20	<40	<20	8	11	16	22	<10	1.9	<10	235	8	2
RM119	<20	<0.3	37	<40	<20	73	12	35	24	<10	2.1	<10	240	8	2
RM126	<20	<0.3	161	51	<20	65	12	70	43	20	6.5	<10	732	8	2
RM127	<20	<0.3	136	68	<20	54	12	65	27	11	6.4	<10	478	8	2
RM140	<20	<0.3	70	218	<20	38	<10	63	8	<10	4.6	17	610	8	3
RM156	<20	<0.3	870	<40	<20	1100	<10	52	68	13	11.2	<10	1200	8	3
RM157	<20	<0.3	27	<40	<20	130	<10	105	24	<10	6.6	<10	1500	8	3
RM159	<20	<0.3	44	<40	<20	47	<10	52	10	26	4.5	<10	87	8	3
RM169	<20	<0.3	42	<40	<20	2900	11	73	25	25	13.0	<10	715	8	3
RM170	129	5.0	109	40	<20	3000	13	75	35	<10	20.6	<10	655	8	3
RM171	<20	1.0	755	69	<20	1700	13	770	38	13	20.5	<10	3600	8	3
RM172	<20	<0.3	133	343	50	52	144	168	15	<10	2.7	<10	1000	8	3
RM193	<20	<0.3	<20	<10	<20	289	60	144	26	60	5.6	<10	1368	8	6
RV002	<20	<0.3	33	<40	<20	72	<10	101	29	28	5.9	<10	1149	8	2
RV004	<20	<0.3	84	<40	<20	105	<10	118	24	65	5.1	<10	453	8	6

All samples returned analyses of <5 ppm Bi except for:

Veins

RB031	20 ppm
RM089	14 ppm
RM090	31 ppm
RM184	8 ppm
RM301	1200 ppm
RM302	17 ppm

Hornfels Zones

RV007	15 ppm

Porphyry and Stockwork Zones

RD002	54 ppm

Gossan Zones

RM170	20 ppm

All samples returned analyses of <5 ppm Cd except for:

Veins

RB015	1100 ppm
RC029	30 ppm
RC035	13 ppm
RC036	18 ppm
RM003	90 ppm
RM310	8 ppm

Porphyry and Stockwork Zones

RM173	12 ppm
RM125	8 ppm

Gossan Zones

RB012	14 ppm

Host Rock Codes:

Host	*Map Unit*	*Lithology*
12	C	Coast plutonic complex
11	B	Felsite intrusions
10	A	Diorite intrusions
9	UK_v	Volcanics
8	UK_s	Sediments
7	LK_q	Sediments
6	LK_{TC}	Volcanics and sediments
5	LK_{RM}	Sediments
4	$LK_{pv,ps}$	Volcanics and sediments
3	$LK_{mv,ms}$	Volcanics and sediments
2	$LK_{v,s}$	Volcanics and sediments
1	$UT_{v,s}$	Volcanics and sediments

MAPS
NOT
FILMED

CARTES
OMISES